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The Action of Adrenaline on the Excised Human Uterus: with a Short Additional Note on the Action of Quinine

BY

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THE response of uterine muscle to adrenaline varies according to the species of animal and functional condition of the organ. The following table, reproduced from Gunn,[1] shows the different types of response which have been found.

The main object of the present paper is to amplify the knowledge which exists on the action of adrenaline on the excised human uterus.

Rubsamen and Klingermann[2] showed that adrenaline caused a rise of tone and increase in individual contractions of strips of the excised human uterus at term (obtained at Caesarean section). Gunn[3] found that adrenaline stimulates the contractions of the excised non-pregnant human uterus and pregnant human Fallopian tube. It appeared from these experiments that adrenaline stimulates the muscle of the excised human uterus whether pregnant or non-pregnant, and that the human uterus corresponds in type to that of the rabbit (Table I).

In contrast to the results with the isolated uterus, those obtained from the organ *in situ* have not been consistent. The method used by different investigators has essentially consisted of recording the contractions by means of a rubber bag inserted into the uterus (either during labour or postpartum), this bag being connected by rubber tubing to a recording tambour.

TABLE I.—ACTION OF ADRENALINE.

Animal	Non-pregnant uterus	Pregnant uterus
Rabbit	Motor	Motor
Cat	Inhibitor	Motor
Rat	Inhibitor	Inhibitor
Sheep	Motor	Inhibitor

Rucker[4] came to the conclusion that adrenaline inhibited the contractions of the human uterus at term. Bourne and Burn[5] came to a similar conclusion although, in the tracing illustrating this effect, the intravenous injection of adrenaline produced a premature and increased contraction before the onset of diminished contractions. Brown and Wilder[6] on the other hand, in experiments on the human uterus in labour or 4–8 days postpartum, found that with intravenous injection "adrenaline gave consistently contraction followed by a com-

pensatory pause." They concluded as follows: "the confusion that has existed regarding the response of the human uterus to ephinephrine resolves itself into an interpretation of what constitutes inhibition. The apparent inhibition claimed by one group, we believe, is the refractory state of muscular activity rather than a drug effect. From our own observations and a more critical interpretation of the curves published in the literature we believe that epinephrine stimulates the labouring and puerperal uterus to contraction." Woodbury and Abrew[7] attempted to reconcile these different results by showing that the effect of adrenaline depended upon the dosage and rapidity of absorption. Thus they found that rapid intravenous injection of 0.1 mg. caused immediate uterine contractions which followed each other so closely that the uterine pressure remained elevated between contractions. The amplitude of the contractions was, however, decreased when doses of 0.01 to 0.02 mg. were administered over a period of 6–10 minutes. They concluded: "These inhibitory effects are in entire agreement with the previously published observations of Rucker, who usually administered the drug by the hypodermic avenue. Divergent results from different laboratories may sometimes be explained by the fact that the drug was administered by different routes."

When the experiments suggesting an inhibitor effect of adrenaline on the pregnant uterus *in situ* were published, it occurred to one of us (J.A.G.) that the difference in the observed effect of adrenaline on the human uterus outside and inside the body might be due to differences in the concentration of adrenaline. In early experiments on the excised uterus much higher concentrations of adrenaline were customarily used than was later found to be necessary. To decide this point tests were made by Gunn and McLachlin in this laboratory to determine the effect on the excised pregnant human uterus of minimal effective concentrations of adrenaline. Though this effect varied with different uteri it was usually from 1 in 10^6 to 1 in 10^7 and the response was uniformly motor. In these experiments, the strips of muscle were obtained during classical Caesarean section and came therefore from the upper part of the uterus. In the course of more recent experiments, similar, except that the low operation was used so that the strips came from the lower uterine segment, the muscle seemed to react to much lower concentrations of adrenaline. It appeared that there was a difference in sensitivity to adrenaline of the upper and lower segments of the uterus at term. Further observations were made, therefore, not only to explore this possibility but also to determine the effect of minimal concentrations of adrenaline on uterine muscle at times other than term.

Methods.

The technique employed was essentially that described by Gunn[3]

The apparatus used for recording the movements of the muscle was of the familiar type used for exsected mammalian tissues. Locke's solution was used as the immersion-fluid. In some experiments, by a modification previously used by one of us (C.S.R.), the glass rod used to fix the one end of the uterine muscle strip was provided with 2 hooks opposite to one another whereby 2 strips could be recorded simultaneously in the same container, thus ensuring that both were under identical conditions with regard to temperature, oxygenation, etc.

Usually the uterine muscle was tested within a few hours of its removal, but often further tests were made after the tissue had been stored for a day or so at 4°C. Two points in regard to the behaviour of the

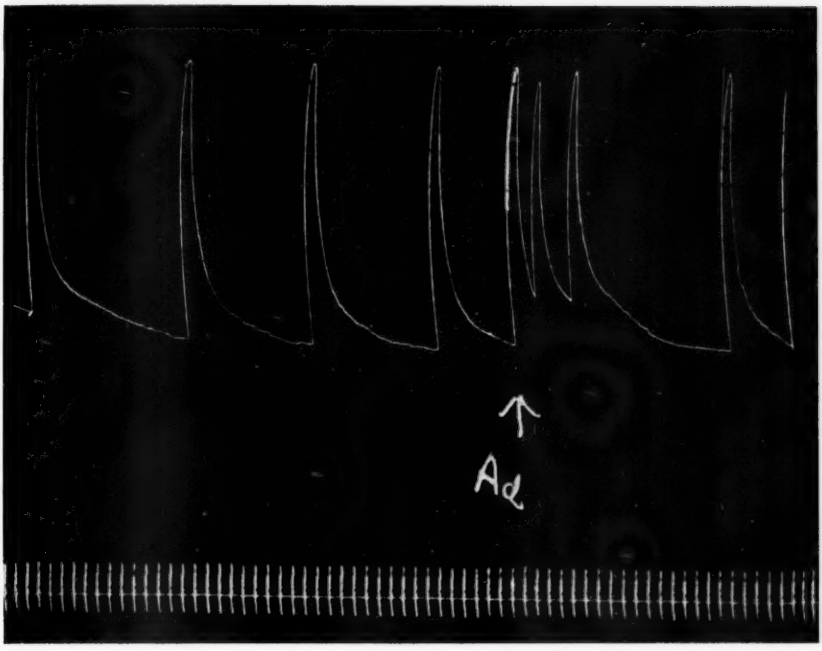

FIG. 1.
Motor effect of adrenaline, 1 in 10 million, on a muscle strip from the non-pregnant human uterus.

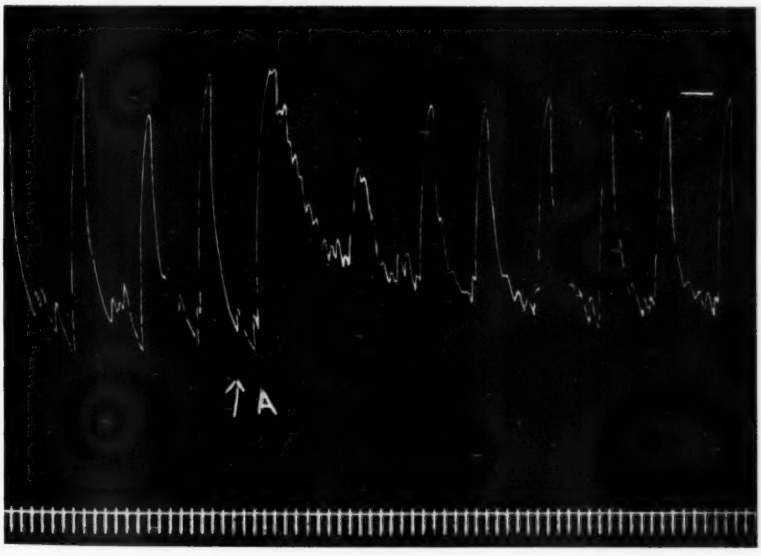

FIG. 2.
Motor effect of adrenaline, 1 in 5 million, on a muscle strip from a uterus in the first 3 months of pregnancy.

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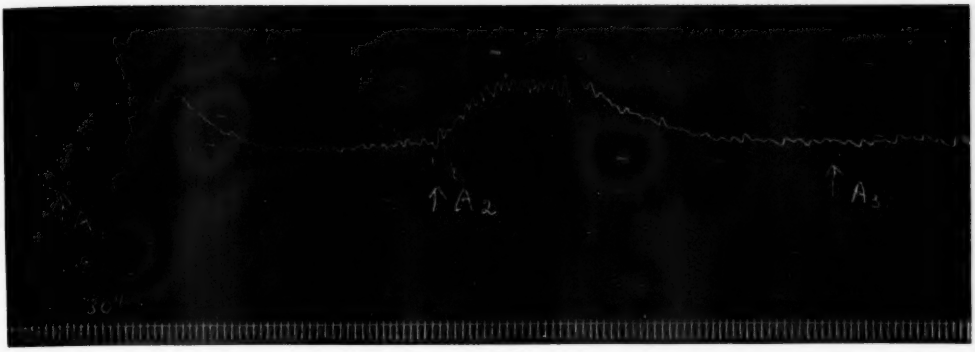

FIG. 4.

Effect of minimal concentrations of adrenaline on a muscle strip from the lower uterine segment of the full-time pregnant uterus. [A_1, adrenaline 1 in 500 million; A_2, 1 in 2,000 million; A_3, 1 in 4,000 million.]

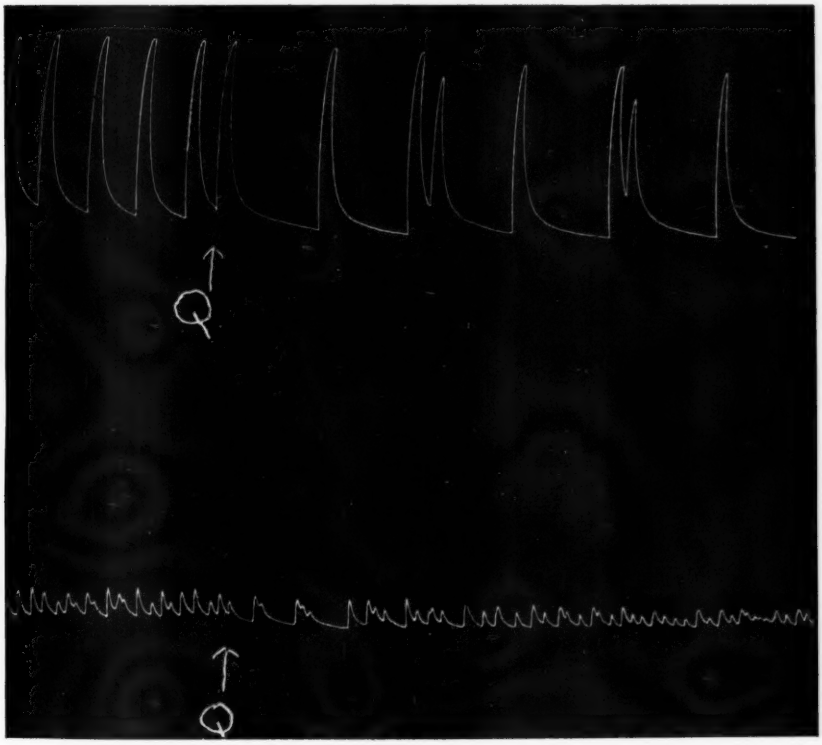

FIG. 7.

Inhibitory effect of 1 mg. quinine hydrochloride on muscle strips from the upper uterine segment (upper tracing) and the lower uterine segment (lower tracing).

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muscle under these conditions may be mentioned. In the first place, when the muscle was placed in oxygenated Locke's solution at body temperature, a latent period, which might be 2 hours or more if the strip had first been cooled, always elapsed before the strip exhibited spontaneous rhythmic contractions; furthermore, when 2 strips from the same uterus were put up each in a separate apparatus, this preliminary period of inactivity was often almost exactly the same for each. This suggested that under these conditions a particular uterine muscle required a fairly definite time in which to reacquire its excitability. From a considerable experience of this kind of experiment, we have come to the conclusion that it is better to arrange the strip of uterus in the recording apparatus and to leave it alone for some hours, if necessary, rather than to instigate rhythmic movements by any kind of mechanical or chemical stimulus. A second point is that, when the uterine muscle is kept in the refrigerator at 4°C. its sensitiveness to adrenaline is not impaired for at least 48 hours.

Results.

1. Non-pregnant Uterus.

No experiments seem to have been published dealing with the action of adrenaline on the non-pregnant human uterus other than those of Gunn.[3] The few experiments we have performed have confirmed his conclusion that the response of the uterus is one of stimulation. This is true also of minimal effective concentrations which are usually of the order of 1 in 10^6 or 10^7. Fig. 1 shows a typical effect of a minimal effective concentration, in this case 1 in 10 million.

2. Pregnant Uterus.

A. *First Trimester.*

Such muscle strips that we have been able to obtain in the first 3 months of pregnancy have shown a motor response to adrenaline in all concentrations above the minimal effective one which is of the order of 1 in 20 million. Fig. 2 shows the effect of 1 in 5 million adrenaline on a uterus 3 months pregnant; the chief effect is a prolongation of the first grouped contraction with a following rise of tone of the muscle.

B. *Second Trimester.*

On 2 occasions muscle strips have been obtained at about the 20th week of pregnancy. The response to adrenaline of one of these strips was weakly motor: that of the other was inconsistent; out of six tests on it over a period of 3 days there was no obvious effect on 3 occasions, a slight motor response once and definite inhibition twice (Fig. 3). In the many experiments

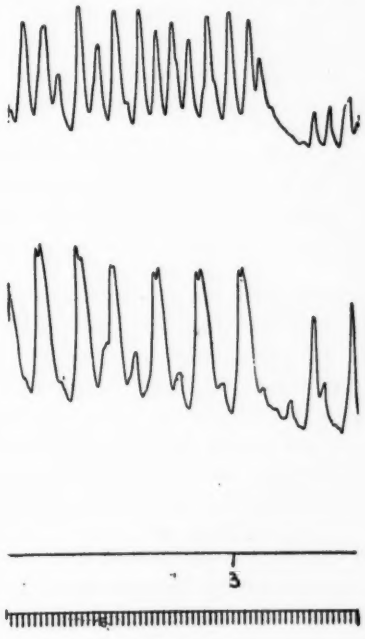

Fig. 3.

Two muscle strips from a uterus 20 weeks pregnant. Tracings showing inhibition to adrenaline, 1 in 500,000. [Pitocin and Pitressin had previously been added without effect.]

we have performed these were the only occasions in which undoubted relaxation of uterine muscle strips occurred following the addition of adrenaline to the bath.

C. *Third Trimester.*

Many experiments on strips taken from uteri during Caesarean section at or shortly before term have been performed to see whether minimal concentrations of adrenaline ever produced an inhibitory effect, and, as has already been explained, to determine whether there was any quantitative difference in response between the muscle of the upper and of the lower uterine segments.

As to the first point, a scrutiny of the present series of experiments, as well as of previous results obtained by Gunn and McLachlin, has shown that the lowest concentrations of adrenaline ever found effective on strips taken from the upper segment was 1 in 50 million, whereas on strips taken from the lower uterine segment, a concentration of 1 in 2,000 million once, 1 in 1,000 million once, and 1 in 500 million several times, has produced an undoubted motor effect (Fig. 4). In no case did we observe an inhibitory response to adrenaline.

With regard to the second point, a difference in sensitivity of the upper and lower segments might be determined either by comparison of minimal concentrations found to be effective in a series of experiments on the two segments of different uteri, or by a comparison of strips taken from the two segments of the same uterus, especially if these could be kept, as nearly as possible, under identical conditions of experiment.

The experiments already described suggested that for a minimal response the muscle of the upper uterine segment requires a concentration of adrenaline of the order of 40 times greater than that necessary for the muscle of the lower uterine segment.

Though it is, for obvious reasons, difficult to get from the same uterus strips from both upper and lower segments, we have, on several occasions, obtained them from both situations. These were placed in the same bath (as described under 'methods') and were throughout subjected to the same manipulations and to the same environment as regards nutrient solution, temperature, oxygen, time of test, etc.; the leverage used for both was also as nearly as possible the same. Under these conditions it was found that a concentration of adrenaline which produced little or no effect on the muscle of the upper segment might produce a conspicuous motor effect on the muscle of the lower segment. This is illustrated in Fig. 5.

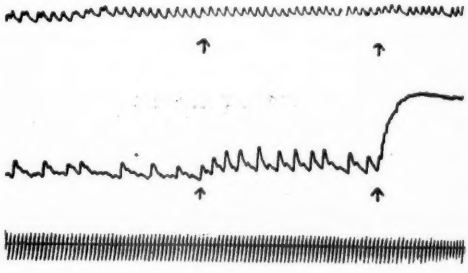

FIG. 5.

Muscle strips from the upper uterine segment (upper tracing) and from the lower uterine segment (lower tracing) of the same uterus before labour. Tracing shows slight motor effect in lower segment strip to 1/10th unit pitressin (first arrow) and a marked motor effect to adrenaline 1 in 10 million (second arrow).

D. *In Labour.*

We have found that muscle strips from the parturient uterus are less likely to show the rhythmic contractions so easy to demonstrate in strips taken before the onset of labour. This may well be caused by the fact that the uterus of a patient requiring a Caesarean section during labour may be tired and partially damaged as a result of

the condition for which the operation was performed. Nevertheless, on several occasions the response to adrenaline has been tested; in no case was there inhibition, and often the motor effect was clear. Strips from the lower segment seemed more sensitive to adrenaline than those from the upper segment (Fig. 6).

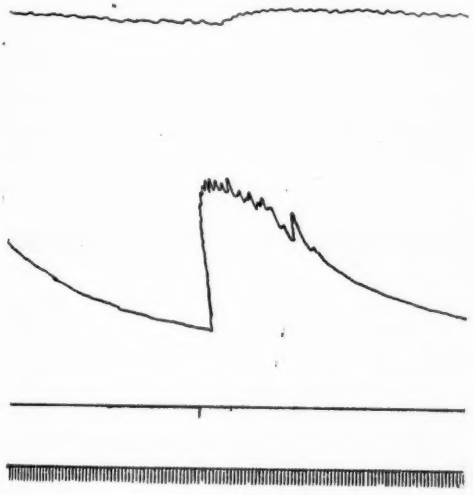

FIG. 6.

Motor effect of adrenaline 1 in 250,000 on muscle strips from the parturient uterus; upper tracing, upper uterine segment; lower tracing, lower uterine segment.

DISCUSSION.

With the confirmation supplied by this paper, there now exists a considerable body of experimentation which is consistently in agreement in finding that adrenaline in any effective concentration stimulates the muscle of the excised human uterus, in the non-pregnant condition, in early and late pregnancy and in labour. The only strips taken during the second trimester of pregnancy gave equivocal results.

When a series of experiments on strips of uterus removed from the upper uterine segment at term has been compared with a series in which the strips were removed from the lower uterine segment, it was found that higher degrees of sensitivity to adrenaline were found in the latter. When strips from the upper and lower segments of the same uterus were tested the latter again proved more sensitive to adrenaline. These experiments taken together would seem to leave little doubt that the muscle of the lower uterine segment is actually more sensitive to adrenaline than is that of the upper uterine segment. It will be recalled that one of us (C.S.R.[8]) has shown that to posterior lobe pituitary extracts, also, the lower and upper segments show similar quantitative differences in response (Fig. 5).

With the uterus *in situ*, the results found by different observers as to the effect of parental injection of adrenaline have not been constant. The evidence that, in certain cases and administered by certain channels, adrenaline stimulates the intact uterus is convincing. Perhaps the preponderating results so far show that adrenaline either increases the contractions or causes a preliminary increase followed by a diminution in tone. It would be more satisfying if a motor effect were universally found as in the excised uterus. The evidence however, that, especially with small doses, adrenaline may produce a wholly or partly inhibitory effect cannot be overlooked. This may be caused by a genuine and direct effect on the uterine muscle. On the other hand, the recorded inhibition of movements may be caused by some factor other than the direct action on the uterine muscle. Among other factors, for each of which analogies could be found in other organs, the following may be mentioned. (1) The method used (a bag in the uterus connected with a tambour) may not give an uncomplicated record of the contraction of the uterine muscle. The record may be effected for example, by movement of the bag following an increase in uterine tone

or by vascular changes. (2) Adrenaline may act indirectly by liberating another hormone which may alter the response to adrenaline. (3) The uterus may be influenced through the central nervous system. Thus Rucker[4] records that puncture of the sacral region with a hypodermic needle (without any injection) may cause inhibition of the uterine movements. When the dose of adrenaline is small, it is conceivable that this central inhibitory effect may overcome any direct stimulating action on the uterine muscle.

Conclusions.

Adrenaline in any effective concentration stimulates the contractions of the excised human uterus in the non-pregnant state, in early and late pregnancy and in labour.

At term, the muscle of the lower uterine segment is more sensitive to adrenaline than is the muscle of the upper uterine segment.

Additional Note on the Action of Quinine (C.S.R.)

Among the many preparations that have been tested on the excised uterus, quinine deserves mention because of its effect on strips from the human uterus at term and in labour.

When amounts of the order of 1 mg. are added to the bath containing 100 c.cm. there is often little or no response; with larger amounts the effect is one of inhibition or paralysis (Fig. 7). When quinine and adrenaline are tested together the one after the other the antagonism between the two substances is very marked (Figs. 8 and 9), an observation which has been made on many occasions by other workers in other spheres.

Whether or not this observation is of any importance in obstetrics is difficult to assess. Among obstetricians there is a considerable difference of opinion as to the value of quinine in labour. Thus Buddee,[9] Bourne

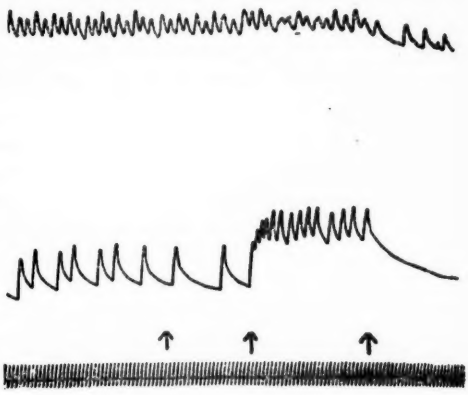

Fig. 8.

Muscle strips from the upper segment and the lower segment of the same uterus taken before the onset of labour. Tracings showing motor effect of adrenaline (second arrow) 1 in 10 million, on the lower uterine segment and the antagonistic effect of 1 mg. quinine hydrochloride (third arrow). At the first arrow a small quantity of pitressin was added without effect.

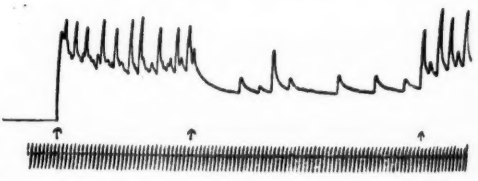

Fig. 9.

Muscle strip from the lower segment of the uterus in labour. Tracing showing antagonism between quinine and adrenaline. First arrow, 1 in 5 million adrenaline. Second arrow, 1 mg. quinine hydrochloride; third arrow, 1 in 5 million adrenaline.

and Burn,[10] and Marshall,[21] doubt the value of quinine either on the duration of labour, the strength of uterine contractions or in uterine inertia, and there are those who will not use it for fear that the foetus be harmed. At the same time, other clinicians (Garner,[12] Mitchell and Bradbooke,[13] Luker,[14]

Green-Armytage,[15] and many others) maintain that quinine is of real value especially in the first stage of labour. It is in the light of this background of differing opinions that the meaning of the antagonism between quinine and adrenaline should be considered. If it is accepted that adrenaline has a motor effect on the lower uterine segment and that this effect is greater than that on the upper uterine segment, and if quinine really antagonises this effect, one is almost forced to the conclusion that, under conditions of overaction of the sympathetic nervous system, quinine should be of use during labour.

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Moulding of the Foetal Head:
A COMPENSATORY MECHANISM.

BY

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IT has long been known to obstetricians that compression-force applied in the sub-occipito bregmatic circumference of the foetal head results in some diminution of the related diameters and is accompanied by a compensatory movement of elongation in the mento-vertical diameter. There is very little description of this mechanism in the literature, and this paper attempts to describe how this compensatory movement is brought about, together with its limitations in vertex presentation.

Anatomical factors. The study of the bones and sutures of the vault can best be made by removing the intact vault still attached to a portion of the base. It is clear that the mobility of any two bones along any suture line will depend largely on the breadth of the connecting membrane between their opposing edges. It is also clear that mobility will be something less than this breadth, for in the case of the lambdoidal, coronal and frontal sutures the breadth of the uniting tissue decreases as the base is approached, and where overlapping is actually produced the thickness of the bone edges must be another limiting factor. The maximum amount of movement along these different suture lines can be measured, and is found to take place at that point of any bone which is most remote from its base, and this is, of course, due to the decreasing breadth of the suture from apex to base. The interesting fact about the movements of these bones of the vault lies in the observation that while the upper portions of the frontal and occipital bones readily respond to forces which tend to depress them, they cannot be made to overlap easily by sliding one bone under the other, and unless very great force is used only slight overlapping is achieved. The impression gained from manipulation of the bones is one of great resistance to any sliding motion. Measurement shows the occipital bone to be capable of an inward movement of $\frac{1}{4}$ inch (6 mm.) at its apex and an inward movement of equal magnitude occurs where each frontal bone reaches the lateral margin of the bregma. From the apex to the base of each bone the depression rapidly decreases. Overlap cannot be accurately measured, but would appear to be no more than $\frac{1}{8}$ inch (3 mm.) at any point where it can be produced. It is sometimes impossible to make the parietal bones overlap along the sagittal suture except by the merest fraction of an inch or with the aid of such force as must rupture the membranous tissue. The reason why the depressing movement should be so much in excess of the sliding movement is possibly due to 3 factors. Firstly, a true sliding motion would be possible only if each bone were entirely mobile instead of being fixed at its base. Secondly, the manner in which the underlying sinuses are attached to the suture tissue tends to limit a sliding movement more readily than the movement of depression. This fact is easily demonstrated by dissecting the dural septum with its enclosed sinus from its attachment along

the floor of the suture. When this has been done the mobility of the bones is greatly increased and they can be made to overlap easily. Thirdly, the decreasing mobility of contiguous bones from apex to base tends to prevent them from sliding one below the other, and where the breadth of the bridging tissue is less than the thickness of the bones, overlap is impossible.

It has been noted that there is some variation from skull to skull of the full time foetus. The sutures are wider in some than in others, and occasionally any one suture may vary irregularly in width from lace to lace. These differences are not necessarily related to weight, but the widest sutures seen were in a foetus weighing 9 pounds 4 ounces. Mobility or plasticity is largely dependent on the width of the sutures, and in some cases overlap can be achieved by manipulation of the bones, but taken over all it rarely amounts to more than $\frac{1}{8}$ inch (3 mm.).

Experimental data. If the scalp be reflected from the skull of a full time normal foetus so that the suture lines are exposed, the immediate effects of compression may be accurately observed. When a force of moderate magnitude is applied in the suboccipitobregmatic circumference there is a movement of the occipital and frontal bones which consists of a bending inwards so that they encroach upon the cranial cavity. This movement is maximal at the apex or highest point of these bones. There is at the same time an upward movement of the vertical portions of the parietal bones and an apparent tendency of the skull to bulge over the area represented chiefly by the posterior ends of the parietals and representing the presenting part in normal labour. As a result of this, the edge of each parietal bone diverges from the other as it passes back from the bregma. The frontal bones tend to come together, and when the force is considerable very slight overlapping occurs along the frontal suture. Overlapping of the bones along the lambdoidal and coronal sutures is not evident, or very slight. It may appear and feel much more pronounced than it really is if the inward movement of the frontal and occipital bones and the outward movement of the parietal bones are exaggerated. Overlap can be accurately gauged only when the edges of opposing bones are brought as far as possible into the same plane, and when this is done it is sometimes surprising to find divergence where one confidently expected overlap. The biparietal diameter is not significantly reduced by moderate compression-force, but when the force is raised reduction of this diameter brings the parietal bones close together and they may slightly overlap along the sagittal suture. The suboccipitobregmatic diameter may be reduced by as much as $\frac{1}{4}$ inch (6 mm.).

The shape and structure of the parietal bone are such that pressure exerted over the parietal eminence produces a lengthening of the bone when measured with calipers from sagittal edge to base, and this is due to straightening out of that part of the curve which lies between a line passing through the eminence parallel with the sagittal suture and the sagittal suture itself, corresponding, in fact, with that area of the vault usually referred to as the vertex. The thickness of the parietal bone is fairly uniform from base to eminence, but decreases at first gradually and then more rapidly from eminence to sagittal suture. This decreasing thickness of the portion comprising the vertex is an important factor in the mechanism of elevation in so far that it helps to determine the direction of movement when a force is applied to the eminence. The vault is raised not by bending, but by unbending (Fig. 1).

The parietal bones were removed from the skull of a recently dead full time foetus

FIG. 1.

Coronal section through parietal eminences. The uninterrupted line indicates unmoulded contour. The chain-dotted line shows effect of applying force to each eminence to the limit of normal moulding, i.e. without producing significant diminution of bi-parietal diameter.

weighing between 7 pounds and 8 pounds. The bones examined were from breech cases, and had not been subjected to any moulding by the natural forces. The membranous suture tissue was pared from the edges of the bone, which was then washed free of blood in saline and dried with absorbent material. One bone was placed on a sheet of paper, concave surface downmost, and its outline traced with a pencil. The bone was steadied with the other hand, and care taken to make no pressure upon it. Weights ranging from 1 pound to 14 pounds were then placed on the convex surface, and the outline traced with each increment. A typical result is shown in Fig. 2. The straightening-out movement is confined to that part of the bone lying between the tuberosity and sagittal suture, and resulted in an average increase in length of about $\frac{3}{16}$ inch (5 mm.) in the small series tested. It is of interest to note that a pressure of 14 pounds over each parietal eminence would correspond approximately to the compression force which might be expected to result from a traction force of about 60 pounds with the forceps applied to the sides of the head.

The parietal eminence is equidistant from the bregma and the posterior fontanelle, but lies nearer to the mid-point of the sagittal suture than to either of these points. This, combined with the fact that the bone is not only convex from side to side but from back to front, results in an increase greater along the anterior and posterior margins than along its middle.

The greatest increase was obtained with weights between 4 pounds and 7 pounds.

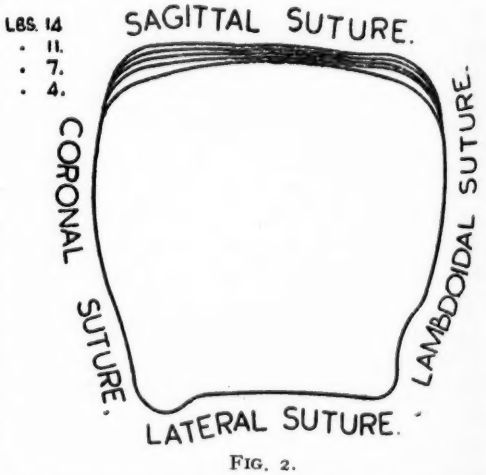

FIG. 2.

Tracing of parietal bone showing effect of placing weights over the eminence. Note that the elongation takes place in the upper vertical portion of the bone. There is no alteration in antero-posterior measurements, nor is there any movement at the lateral suture.

Additional weights up to 14 pounds produced little more increase. There can be no other mechanism contributing to this increase of the mento-vertical diameter since the temporo-parietal sutures and the

sutures of the base are much too firmly bound to yield without rupture. Moloy[1], in his radiological study of moulding, has found separation along this lateral suture in cases of severe moulding, a finding which must appear as uncommon to anyone who has attempted to measure the force necessary to effect this separation. Some increase in intracranial tension may be a factor promoting elevation of the vertex, but it is not possible to demonstrate this. The maximum increase in the mento-vertical diameter would seem to be only about $\frac{3}{16}$ inch (5 mm.). It would appear, therefore, that the displacement of cranial content produced by the inward movement of the occipital and frontal bones is compensated for by an increased volume represented by 2 wedge-shaped areas extending the length of each parietal bone, with a base $\frac{3}{16}$ inch (5 mm.) at the sagittal suture and the apex at the lateral margin of the vertex. There is no reliable volumetric method of comparing the displacement with the compensation, but the impression is gained that they must be about equal.

There are certain obvious fallacies in measuring parietal elevation in the way described above. That it gets very near to the truth can be shown by fixing the foetal head against resistance and applying the blades of the forceps to the sides of the head. Traction forces between 60 pounds and 70 pounds increase the mento-vertical diameter by about $\frac{1}{4}$ inch (6 mm.).

Limitations of parietal elevation. In an interesting paper describing antero-posterior compression of the foetal head, Milne Murray writes: "It may safely be assumed that these (cranial contents) are practically incompressible and that if their containing space is limited in one direction a corresponding expansion must be found for them elsewhere. This expansion is undoubtedly provided by an elongation of the skull in a vertical direction." He further believed that the elongation was proportionate to the compression. By screwing up clamps placed over the occiput and the face he had established experimentally that the antero-posterior diameter could be reduced from $4\frac{1}{2}$ inches (10.8 cm.) to 3 inches (7.6 cm.) without affecting the biparietal diameter. At the limit of reduction one eye protruded from its socket, but he did not appear to regard this as a compensatory mechanism to extreme force, which, in fact, it is, and is also evidence of the inadequacy of mento-vertical elongation to compensate excessive antero-posterior diminution. There can be little doubt that vertical elevation is a limited mechanism and affords very little margin before compression of the cranial contents begins.

If antero-posterior compression is carried out experimentally with a stricter regard for the conditions pertaining to labour in cases of flat pelvis, the results are rather different from those obtained by Milne Murray. If we assume, as we are entitled to, that in the mechanism of labour in cases of flat pelvis there is also a compression force in the transverse diameter of the head, and that, because of the lateral shift of the head, this force falls anterior to the bi-parietal diameter, the conditions can be fairly accurately reproduced. When the head is compressed transversely and anterior to the bi-parietal diameter, moderate antero-posterior compression fails to produce any telescoping effect, and this is due to the fact that the side to side compression slightly reduces the bi-temporal diameter so that when antero-posterior compression is applied the edges of the frontal and parietal bones impinge upon each other in the lower parts of their suture lines, and so greatly limit any movement calculated to reduce the antero-posterior diameter except by the use of very great force. Moloy[1] describes this locking effect

occurring, not only anteriorly but also posteriorly, along the lambdoidal suture. In the writer's own experiments, it occurred only if the transverse compression were applied first, as it probably is in the circumstances of labour described above. The manner in which the frontal and parietal bones articulate favours antero-posterior movement.

An interesting and significant observation was made when carrying out this experiment. When antero-posterior compression is begun, the first movement of the frontal and occipital bones is to bend inwards, and when the apices of these bones have become depressed to the extent of about $\frac{1}{4}$ inch (6 mm.) continued compression causes them to drag on the parietals, and the edges of these bones can be seen to be pulled down. This drag on the parietals must indicate the limit of safe antero-posterior compression.

Excessive inward movement of the occipital and frontal bones tends to prevent

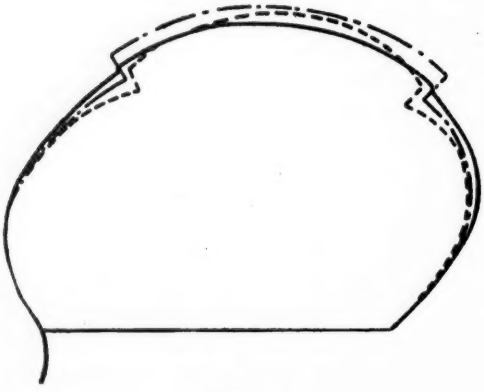

FIG. 3.

The uninterrupted outline shows normal skull contour. The dotted outline represents excessive moulding—the parietal bones are being pulled down by the inward bending of the occipital and frontal bones. The chain-dotted outline shows theoretical effect of reducing compression force and restoring normal moulding effect by releasing tension on membranous sutures (Diagrammatic).

elevation of the vertex by dragging on the parietals so that in a well-balanced response to compression both movements will share equally the intervening membranous suture and each movement will be stopped simultaneously when the suture is fully stretched, or there will be interplay below this level (Figs. 3 and 4). It is probable also that

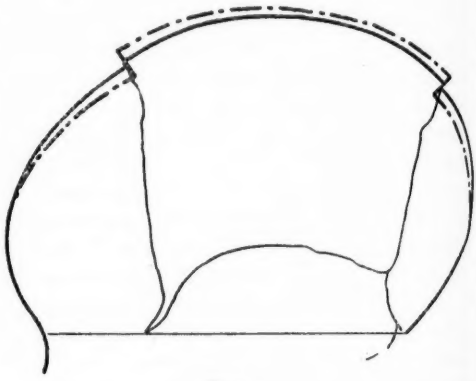

FIG. 4.

Maximum normal moulding. The uninterrupted line indicates unmoulded skull contour. The chain-dotted line shows depression of occipital and frontal bones with elevation of parietal. The membranous suture is fully stretched and equally shared by each movement.

pressure over the convexities of the frontal and occipital bones will cause some slight lengthening of these bones, but, with the head fully flexed these convexities lie above and below the main incidence of compression so that they are not likely to respond to the same degree as the parietals. At the same time, it must be observed that, with the head fully flexed, the incidence of compression will fall chiefly on the upper mobile portions of the frontals where they form the anterior angle of the bregma, so that depression is easily accomplished, and is in some respects the favoured movement. It is probably for this reason that the parietals are often brought close together

along the anterior end of the sagittal suture, and where the head has been exposed to relatively great compression force there is commonly slight overlapping here. In such circumstances, overlapping of the parietal bones along the sagittal suture must indicate that reduction of the cranial cavity has begun.

In the case of the occipital bone, the main incidence of compression will fall below the tuberosity and will tend to lengthen the bone by straightening out the curve. The pull on the parietals along the lambdoidal sutures would therefore only begin some time after the anterior pull had begun. Approximation and even slight overlapping of the parietal bones is much more easily produced at the anterior end of the sagittal suture than at the posterior end.

There was one other observation made which is not without interest. When pressure is made on the occipital bone so that it is depressed inwards, the apex of the bone "claws" down the tentorium. Very great force is required to effect this experimentally, however. Nevertheless, it is possible that, in some cases, particularly where a wide membranous suture allows greater mobility of the bone, powerful suprapubic pressure on the aftercoming head or its extraction by excessive traction on the shoulders may give the bone sufficient impetus to tear through the junction of falx and tentorium. It is interesting to note in this connection that, when compression-force is so great as to produce excessive moulding, the parietal bones are anchored down by the inward movement of the frontal and occipital bones. In these circumstances, intracranial tension will continue to rise with the compression-force, and as a first effect of the 2 opposed forces —the downward pull exercised by the occipital and frontal bones and the upward thrust of rising intracranial tension towards the least resistant part of the skull, together with the effect of bi-parietal compression—bending of the vertex will occur. While this mechanism may contribute to the tearing of the dural septa, it is not the whole story, for tears are very difficult to produce experimentally.

It is not uncommon to see foetal heads with appearances of great elongation. Recently the writer delivered a rickety dwarf after a prolonged and difficult labour. The foetus was stillborn and the head greatly elongated, particularly on the left side. On cutting the scalp transversely from ear to ear through the summit of this convexity the elongation was found to be due chiefly to the accumulation of blood clot and sanious fluid between the scalp and the skull. There was no haemorrhage beneath the pericranium, nor was the scalp infiltrated with blood or oedematous fluid.

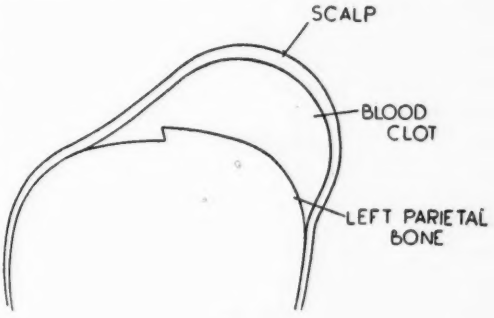

FIG. 5.

Coronal section through parietals showing conditions present in a case where great elongation of the skull was apparent. Note that the blood clot and serous fluid lie between the scalp and the pericranium. The scalp tissue itself is little changed.

The left parietal bone was raised above the level of the right along the sagittal suture, this being more pronounced anteriorly than posteriorly and the maximum elevation estimated at $\frac{3}{16}$ inch (5 mm.). There was slight overlapping of the bones anteriorly,

but they tended to diverge posteriorly. Slight overlapping was also present along the frontal and lambdoidal sutures, and was probably no more than $\frac{1}{16}$ inch (1.5 mm.). The falx and tentorium were intact and no macroscopic lesion found in the brain. This case illustrates the possibility of mistaking the effects of injury for those of moulding (Fig. 5).

In conclusion, it should be stated that the observations described in this paper refer to the full-time foetus weighing between 7 pounds and 8 pounds. There is some evidence that postmaturity greatly reduces the movement of parietal elevation.

I am indebted to Professor R. W. Johnstone for criticism and advice. This paper is published through the courtesy of Dr. Johnstone, Medical Officer of Health, Greenock.

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Acute Inversion of the Uterus

BY

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CHISHOLM[1] has recently reported a case of acute inversion of the uterus, and makes interesting comment thereon. It is obvious from all statistics, and from the personal experience of all obstetricians, that this condition is, as he says, "very rare and important," the incidence being variously given from 1 in 10,000 to 1 in 100,000 deliveries. As a consequence of its rarity the diagnostic standards laid down in many textbooks may be misleading, and there may be much uncertainty regarding its treatment. I propose to report 2 cases which I personally have observed, and to make certain comments on the condition in the light of my experience.

Case 1. 2-para, age 22 years.

Obstetrical History. First pregnancy had terminated in January 1940 in the spontaneous birth of a full-time living child. Third stage of labour lasted 35 minutes, and was normal. On the 4th day she showed a rise of temperature which was found to be due to a haemolytic streptococal infection. This came rapidly under control, and she was discharged well upon the 18th day.

Second confinement. Following uncomplicated 1st and 2nd stages of labour, a living child weighing 6 pounds 5 ounces was born spontaneously at 1.20 p.m. I happened to be in another part of the labour ward at the time of the birth, and so was in a position personally to observe subsequent happenings. The 3rd stage of labour was uneventful for 25 minutes—in this clinic "control" of the fundus is forbidden in the 3rd stage, the fundus is "observed." No attempt was made to express the placenta. My attention was now called to the patient, as she had had a small amount of vaginal bleeding with which she passed into profound shock. A blood-pressure reading was not obtainable. The possibility of inversion was immediately considered, but as the uterus was considered to be normal on abdominal palpation, and as nothing abnormal was visible at the vulva, this diagnosis was regarded as improbable, and it was decided to proceed with anti-shock treatment, and await developments. The usual treatment was at once available, the patient getting serum 1 pint, rapidly followed by a pint of blood by drip. She showed signs of recovery which were progressive for 45 minutes; the uterus still appeared normal to abdominal palpation, the placenta was still retained, and there was no further haemorrhage. She now cried out with severe abdominal pain, and passed quickly into shock so profound that her condition seemed hopeless. Palpation of the uterus did not even now suggest inversion of the uterus, and there was still nothing visible at the vulva. The uterus felt *per abdomen* much as it had felt originally. No sign of "cupping" could be found, even though it was deliberately looked for, and the patient was unusually thin.

Vaginal examination was now made; it

revealed a complete inversion of the uterus. (In the Chisholm case the author speaks of complete inversion as including also prolapse. O'Sullivan[2] in a recent article uses the term complete inversion in a similar manner, which I submit is incorrect. In this case there was no prolapse.) The placenta was attached to the fundus and there was no bleeding. I made an attempt to replace the uterus with the placenta *in situ*, but as this presented some difficulty I removed the placenta, and was then able to reduce the inversion easily. The patient's condition showed immediate improvement following reposition. She very soon regained consciousness, and seemed to be out of immediate danger; anti-shock measures were continued, another pint of blood being administered. Full doses of sulphonamides were started. Convalescence was unsatisfactory, the patient being febrile from the 2nd day of the puerperium, and symptoms of diabetes insipidus became apparent from the 6th day. She died on the 10th day.

Postmortem examination was made. The uterus was found in good position, and showed evidence of localized inflammatory processes. Complete necrosis of the anterior pituitary had taken place with partial necrosis of the posterior lobe.

For an account of the diabetes insipidus and pituitary necrosis found in this case see the following article on page

Case 2. 3-para, age 34.

Obstetrical History.

First confinement, April 1939. Forceps delivery; severe postpartum haemorrhage; manual removal of placenta; puerperium afebrile.

Second confinement, June 1940. Spontaneous; 3rd stage normal; puerperium normal.

Third confinement. Spontaneous delivery after easy 1st and 2nd stages of labour. Following the birth of her baby the patient quietly rested for 15 minutes; there was then a slight vaginal blood-loss with which she passed into profound shock, blood-pressure reading being unobtainable. My assistant, Dr. T. Boland, who had been present since shortly before the birth of the baby, initiated anti-shock measures at once, and telephoned me. He reported the patient's condition and was quite definite that the uterus appeared quite normal to palpation, and that nothing abnormal was apparent at the vulva, nor was any haemorrhage taking place externally. I instructed him to, at once, make a vaginal examination, and to replace the uterus should he find it inverted—to await my arrival would have involved about 15 minutes delay. He found that complete inversion had taken place, and that the placenta was attached over the inverted fundus. He removed the placenta and reduced the inversion.

On my arrival, 15 minutes subsequent to the telephone call, I found the patient conscious, still shocked, but her systolic blood-pressure was now 80 mm. She was given a pint each of serum and blood and was fully recovered in 24 hours time. Sulphonamides were administered in the puerperium, which was uneventful.

Discussion.

Aetiology. Most writers agree that a fundal insertion of the placenta is a necessary predisposing factor in inversion of the uterus. In both the cases herein reported the placenta was so situated.

Given a fundal insertion of the placenta various determining causes have been cited for the actual occurrence of the condition: (*a*) An atonic state of the uterus, during which state pressure is made upon the fundus or traction is exerted on the cord. (*b*) Precipitate labour whilst the patient is

in the erect position. (*c*) Tumours at the fundus uteri. In the 2 cases here reported it is certain that none of these determining causes were present, and that both cases were determined by a normal uterine contraction in the 3rd stage of labour.

Ordinarily such a contraction will crowd the placental cotyledons together and will so reduce the size of the placental site that separation of the placenta will take place towards the centre of its site of insertion. If, however, there is any factor which interferes with this central separation of the placenta the result of the uterine contraction will be to invaginate the placenta into the uterine cavity and to carry with it the placental site to which it is firmly attached. Such interference with placental separation could be brought about by localized atony at the placental site—which appears to me a most improbable occurrence; or by abnormal adhesion of the placenta to its site —this latter state of affairs could be brought about by minor degrees of placenta accreta. Such localized areas of placenta accreta are now generally recognized. It is not my purpose to discuss the causation of placenta accreta—but it is of interest to note that in both of the cases here reported 2 of the usually cited predisposing conditions for placenta accreta were present—the one had a severe infection at her 1st confinement, and the other had a manual removal of the placenta.

Whilst, therefore, it is of course possible that gross mismanagement of the 3rd stage of labour can cause the condition, the extreme rarity of the accident would rather suggest that it is just as often of spontaneous occurrence.

Diagnosis. Williams stated long since that inversion of the uterus must always be suspected and looked for when unexplained shock arises in the 3rd stage of labour. This simply means that the patient should be examined at once vaginally. The history of the 2 cases here reported bears this out very clearly. In the 1st and fatal case, the failure to note any "cupping" of the uterus in an exceedingly thin woman tempted one to treat the shock on the assumption that inversion had not taken place whereas, in fact, an incomplete inversion had already occurred. It did not proceed to complete inversion until by our anti-shock measures we had brought the patient round to such a condition that her uterus became active again. It was then too late. We were still able to recover the patient from her immediate shock, but the pituitary had been destroyed.

Treatment. There appears to be much difference of opinion as to how these cases are to be treated. All will agree that the shock must be dealt with at once, but many will hold that operative interference must not be undertaken until such measures have shown or have begun to show a result. This attitude seems to be based upon the treatment of surgical casualties. But the conditions are not analogous. In the casualty, operative interference usually will be called for to prevent toxic absorption from damaged or crushed tissue, or to replace broken bones etc, that is in such cases the inflicting agent of the primary shock has already ceased to act. In the case of the acutely inverted uterus it is certainly arguable that the "inflicting agent" of the shock is still in action, and will remain in action for a considerable time unless the uterus is replaced. The shock would appear to be due, as Chisholm says, to the stretching of the nerves in the broad ligament and peritoneum which have been dragged into the inverted uterus. The effect of putting these structures on the stretch is well known to all obstetricians. It is, therefore, part of the treatment of the shock in these cases to remove the cause of

the shock, that is, to restore the uterus to its normal position as gently and quickly as possible. My experience in the 2 cases reported would certainly suggest that such restoration of the uterus is the most important part of the treatment.

This restoration can be most easily carried out after removal of the placenta. Undoubtedly, if restoration could be accomplished easily with the placenta *in situ* the possibility of infection would be lessened, but this presupposes that such a placenta will then leave the uterus without manual intervention. I think very few obstetricians would have the temerity to await normal separation in such a case.

I have been much impressed by the method of replacement described by O'Sullivan in the article already cited—replacement by the hydraulic pressure exerted through a douche. It will be noted that in both the cases in which he used the method the placenta had already been removed. If a douche is ready I think this simple method should be at once tried, but if the preparation of the douche entails any delay I think it probably wiser to proceed manually and at once.

SUMMARY.

Two cases of spontaneous inversion of the uterus are reported.

In both the inversion was complete without prolapse. In both "cupping" of the uterus was not noted by abdominal palpation although the patients were thin.

In the 1st case the absence of the 2 signs above mentioned prompted delay in vaginal examination and reduction. It is argued that this delay was responsible for the death of the patient.

In the 2nd case vaginal examination was made at once although both signs were absent, and immediate reduction was carried out.

From the morbid anatomy of the condition, and from the experience gained in these 2 cases it is argued that such immediate reduction is the most important part of the treatment of the shock resulting from this accident.

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Diabetes Insipidus in Association with Postpartum Pituitary Necrosis

(A report of two cases)

BY

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It is now established that postpartum ischaemic necrosis of the anterior pituitary is a relatively frequent complication in cases where delivery is attended by a severe degree of collapse. An extensive literature has accumulated dealing with the subject and within recent years the work of Sheehan and Murdoch[1] has contributed much towards the elucidation of the problem. Sheehan notes that the collapse in a large proportion of cases is due to haemorrhage, though this is not always so, and in one of the cases here reported haemorrhage had obviously no aetiological rôle in the production of the pituitary necrosis. Patients in whom the lesion occurs may die soon after clinical signs of the necrosis are first manifest or they may survive for years. In the latter case one expects the development of a clinical picture pointing to a chronic state of anterior pituitary insufficiency, and in fact the more severe cases show all the characters of the syndrome generally referred to as Simmonds's disease. In the original description of this condition, Simmonds[2] reported a shrunken and almost entirely fibrosed pituitary occurring in a woman aged 46 years who displayed marked emaciation, a subnormal temperature, and in general an appearance suggesting a prematurely senile state. The autopsy revealed that a very large proportion of the anterior, middle and posterior lobes of the pituitary had been destroyed. The clinical condition could be related to the birth of this woman's fifth child. Following that delivery she had suffered a severe puerperal infection. Simmonds therefore supposed that a septic necrosis had occurred in the pituitary.

Since that first report many authors have described cases of this condition and its relation to parturition has been shown, though it is now agreed that collapse rather than infection at the time of delivery is the determining factor in its occurrence. Consequently, in a careful follow-up of 128 cases in which collapse (for the most part associated with haemorrhage) had occurred at the time of delivery, Sheehan was able to demonstrate that in no fewer than 41 cases which survived there appeared subsequently symptoms which suggested strongly a greater or less degree of anterior lobe pituitary necrosis. In a reverse follow-up in 15 cases of parous women exhibiting clinical evidence of hypopituitarism he found that in 13 of these cases severe haemorrhage had complicated the preceding delivery. He correlated the severity of symptoms with the degree of collapse which had occurred.

The striking clinical feature of the two cases reported in this paper was the occurrence of an extreme degree of polyuria and the finding at autopsy of necrosis in both the anterior and posterior lobes of the pituitary body. The occurrence of symptoms of diabetes insipidus in association with postpartum necrosis of the pituitary has not previously been commented on.

Case Reports.

Case 1. Booked case. 2-para, aged 22 years. Acute inversion of the uterus.

Following spontaneous delivery of a living child acute spontaneous inversion of the uterus occurred. At no time did the patient suffer from haemorrhage. The inversion was at first partial. With this partial inversion she passed into profound shock, a blood-pressure reading being unobtainable. Treatment of the shock was at once instituted—a vaginal examination was not made at this stage. About 45 minutes later, when her general condition had improved considerably, she cried out with pain and passed into shock so profound that her condition seemed hopeless. Vaginal examination now revealed a complete inversion of the uterus. The inversion was reduced. Following reduction her condition showed improvement and she soon appeared to be out of immediate danger. Convalescence was, however, unsatisfactory—from the 6th day of the puerperium until her death on the 10th day she showed *inter alia*, clinical evidence of diabetes insipidus. Her output of urine in these four days was 916 fluid ounces, that is 229 ounces per day. In the light of the postmortem findings the clinical features which interest us here are (1) profound and prolonged shock without haemorrhage, and (2) polyuria and polydipsia.

The autopsy revealed the following findings: On opening the cranium the cerebrum appeared normal on inspection and on macroscopic section. The pituitary was approximately normal in size. The cerebellum was normal.

The lungs were pale in colour and macroscopic section showed no pathological feature. The heart was normal.

The abdominal viscera appeared normal except for slight congestion in the kidneys. It was found that the inversion of the uterus had been completely reduced. On incising the uterus a patchy purulent exudate was found covering the mucosa except in a few smooth and shiny areas. The placental site was evident at the fundus but did not present any gross evidence of infection. There was a small haematoma at the right cornua.

The uterus and its adnexae, portions of the lungs, myocardium, liver, spleen, kidneys, pancreas and the entire pituitary gland were removed for microscopic examination.

Following is the report on the histological findings:

Liver. Sections show little or no pathological change. The liver cells may be somewhat shrunken and the sinusoids dilated.

Spleen. Shows some congestion.

Kidneys. Sections show very little pathological change. Here and there the lining cells of an occasional tubule are degenerate and hyaline casts are present. There is some slight old-standing fibrosis near the pelvis.

Uterus. This postpartum organ was enlarged. It was lined with necrotic tissue. Sections show this necrotic tissue beneath which there is a zone infiltrated with pus cells and chronic inflammatory cells.

Pituitary. This was about normal in

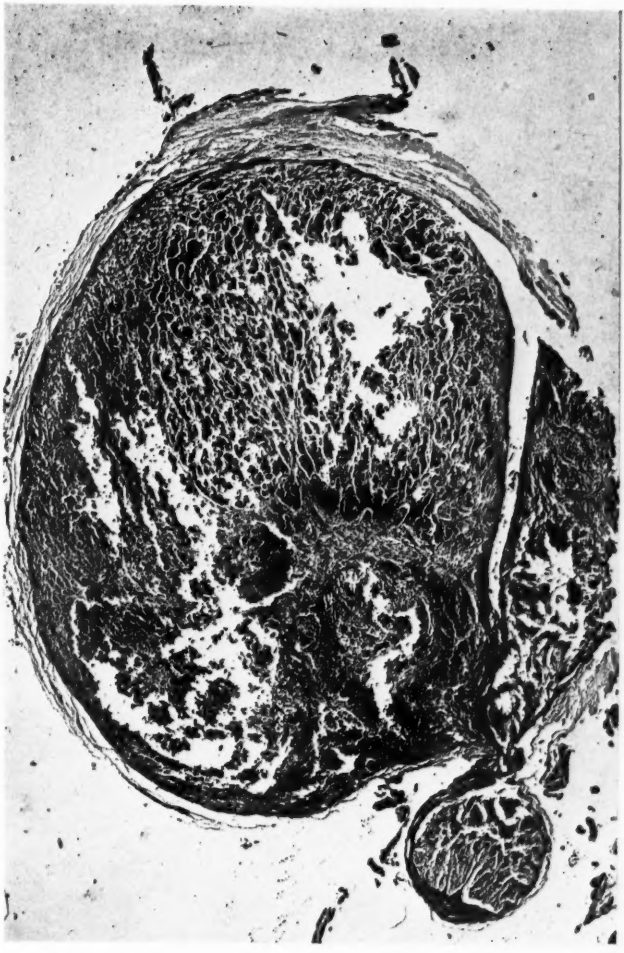

FIG. 1.

Saggital section through the pituitary gland showing widespread necrosis of the pars anterior. Haematoxylin and eosin.

Photomicrograph × 12

S. & G.

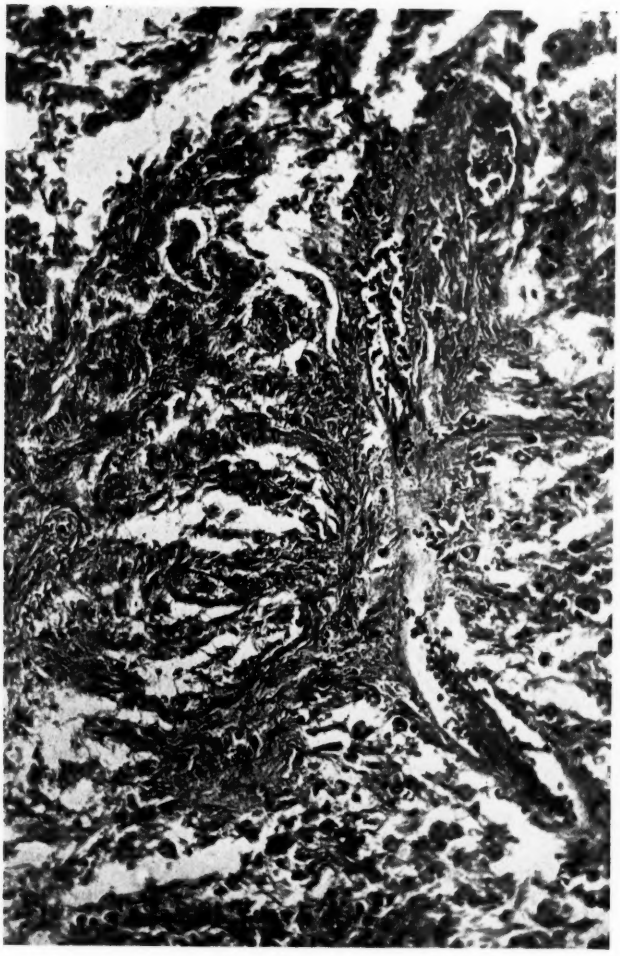

FIG. 1A.

Photomicrograph × 190 of pars nervosa showing degeneration and loss of nuclear staining.

S. & G.

FIG. 2.

A coronal section of pituitary gland showing massive necrosis of pars anterior. The arrow indicates the portion of the pars nervosa shown in Fig. 2A. Haematoxylin and eosin.

Photomicrograph × 10

S. & G.

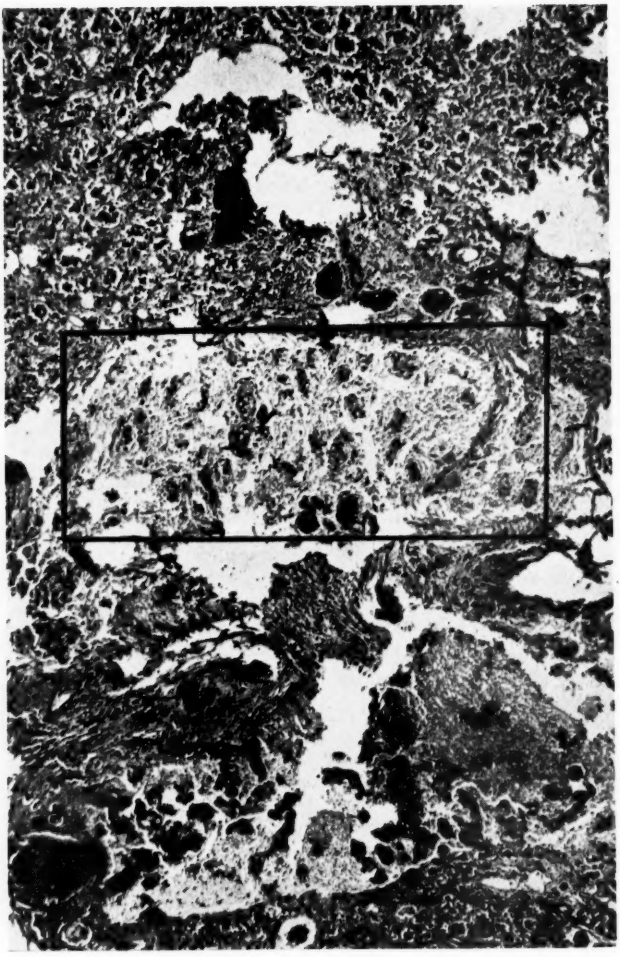

FIG. 2A.
Showing necrosis of the infundibular portion of the pars nervosa.
Photomicrograph × 50.

S. & G.

size, measuring 10 × 8 mm. Sections show that there is massive necrosis of the anterior lobe. The outline of the cells forming the alveoli of the anterior pituitary are still visible, but they are entirely necrotic and the nuclei have disappeared. The inter-alveolar septae are still visible. Only occasional groups of healthy cells remain about the periphery of the gland. The posterior lobe shows a partial degenerative change with loss of the normal compact structure of the neuroglia and a notable deficiency of pituicytes in the degenerate area. It is to this latter lesion that attention is particularly directed in view of the polyuria which was a striking feature in the clinical course of this case. See Figs. 1 and 1a.

Case 2. Emergency admission; 4-para; aged 34 years. Combined accidental haemorrhage.

This patient, who had not received antenatal care, was found unconscious in a field near her home on a cold, wet day. How long she had so lain is not known. She was taken to a district hospital, where, shortly after admission, she had an eclamptic fit. She was then transferred some 60 miles to the National Maternity Hospital, Dublin.

On admission to this hospital the patient was conscious, very cold, and suffering from some shock. She complained of intense headache. Examination showed her to be about 36 weeks pregnant. Slight vaginal bleeding was taking place. Oedema was marked but not gross; 8 ounces of urine were obtained by catheter. Albumin was present in the urine in large amount (boiling solid). Blood-pressure reading shortly after admission was 130/80. The uterus was tense and tender but definitely active. The cervix uteri was dilated to 3 fingers. The foetal heart was not heard. Shortly after admission the membranes ruptured and 1½ hours later the head was on the perineum. The patient was delivered by low forceps of a stillborn child weighing 6 pounds and 4 ounces. Third stage of labour lasted 5 minutes and the placenta was followed by a large clot.

The patient died 84 hours after delivery. Acute pulmonary oedema developed 12 hours before death. During these last 12 hours she was unconscious and incontinent of urine. In the 72 hours preceding unconsciousness she passed 593 ounces of urine, that is 190 ounces per day. She complained all this time of thirst and headache. This case presents similar clinical features to Case 1, that is (1) profound shock and (2) polyuria and polydipsia.

At autopsy the pituitary appeared slightly larger than normal for the 3rd day of the puerperium. It was of a deep plum colour. Little other abnormality was noted and the pulmonary oedema of which clinical evidence had been observed was not present in a gross degree. There was slight enlargement of the mesenteric lymph nodes. Some of the later structures, together with portions of the liver, kidneys, pancreas and the pituitary, were removed for microscopic examination.

The liver, pancreas and mesenteric glands were histologically normal. Sections from the pituitary showed an almost complete necrosis of the anterior lobe of the gland. There were a few small islets of surviving cells, but the bulk of the tissue was markedly degenerate with a very striking infiltration by polynuclear leucocytes. This leucocytic reaction was most marked in the periphery of the gland. (See Fig. 2.) Examination of the posterior lobe showed an area in which degeneration of the neuroglia and deficiency of pituicytes was observed. The appearance was similar to that noted in Case 1. (See Fig. 2a.)

In each case the postmortem examination was begun within a short time of the patient's death. As the possible existence

of pituitary necrosis was suspected in each case it was desired to obviate the occurrence of postmortem autolytic change in the anterior lobe cells. In Case 1 the pituitary was actually removed and placed in fixative within 45 minutes of the patient's death.

The occurrence of a marked polyuria in these cases is of interest in view of the fact that a lesion can be demonstrated in the pars posterior of the pituitary. It has been known for some 50 years that injection of extracts of the posterior lobe into animals produces an antidiuretic effect provided the dose is sufficiently large. Small doses tend to produce a diuretic effect presumably because the rise in blood-pressure results in increased flow through the renal filter. The precise mechanism by which the antidiuretic effect is exerted is not clear. It may be due to a vasoconstriction of the afferent renal arterioles.

Much experimental work has been carried out in an effort to decide whether the pressor, oxytocic and antidiuretic effects of extracts of the posterior pituitary are due to the action of a number of different hormones or to the manifold action of a single substance. Kamm[3], Stehle[4] and others have claimed the separate isolation of two different fractions, one having a potent pressor effect with little action on the plain muscle of the uterus and the second producing a significant contraction of uterine muscle with minimal rise in blood-pressure. These fractions have not yet been isolated in a state of crystalline purity. Of these two substances it is commonly held that the antidiuretic effect is exerted by the pressor fraction.

On the other hand certain evidence is available which suggests that only one hormone is in operation. Van Dyke *et al.*[5] have recently reported the isolation of a single substance possessing pressor, oxytocic and antidiuretic effects.

Of the clinical disorders which can be correlated with hypofunction of the posterior lobe, diabetes insipidus is the most striking. The profuse polyuria with attendant polydipsia may be the only symptoms. The condition can be readily connected with lesions of the posterior lobe and of the adjacent hypothalamus. It appears that the polyuria resulting from ablation of the posterior lobe of the pituitary is less enduring than that which follows interference with the hypothalamus. Camus and Roussy[6] state that the latter type cannot be controlled by injection of posterior lobe extracts. It now appears that loss of nervous control following damage to the hypothalamus determines the occurrence of hypofunction of the posterior lobe (Cushing). It is of significance that in the experimental animal the polyuria following ablation of the posterior lobe is relieved by removal of the remainder of the gland. This suggests that some action of the anterior lobe hormones is necessary in the production of the diabetes insipidus syndrome. In this connection it may be worthy of note that in the two cases here reported a small proportion of the anterior lobe cells survived.

Summary.

Two cases of postpartum necrosis of the pituitary are reported. In each case both the anterior and posterior lobes of the gland showed degenerative lesions.

In each case polyuria and polydipsia were prominent features in the clinical picture.

Profound shock occurred at the time of delivery in both cases. In Case 1 this was associated with acute inversion of the uterus, and in the second case with combined accidental haemorrhage occurring in unusually unfavourable circumstances.

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A Study of Normal and Abnormal Menstrual Function in the Auxiliary Territorial Service

BY

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DURING and since the war large numbers of young women have been brought together in the Services under military control and discipline, giving unusually favourable opportunities for medical and sociological inquiries. One such inquiry into normal and abnormal menstrual function is described in this paper.

The objects of the inquiry were as follows:

(1) To obtain data regarding normal menstrual function in young women and the incidence of dysmenorrhoea and its relation to social and personal background.

(2) To ascertain whether service in the Auxiliary Territorial Service has any significant effect on menstrual rhythm, and whether there is any correlation between such disturbance and social or personal factors.

METHOD.

Over 700 recruits and Serving Auxiliaries were personally interviewed by myself. Clinical examination was not made, but a full history was obtained of social background and general health, as well as details regarding menstrual history. The women interviewed included representatives from 12 different units, comprising officers and other ranks, and most of the main employment groups of the A.T.S.

The women talked freely and, it is believed, truthfully. A questionnaire used to record answers was so planned that the accuracy of certain statements could be checked by others approached from a different angle. Not any inconsistency was found.

The information obtained regarding menstruation can be considered under three headings: (*a*) Dysmenorrhoea; (*b*) Irregularity of Cycle; (*c*) Menstrual Disorders at Entry to the A.T.S.

A. DYSMENORRHOEA.

1. *Frequency and Severity of Dysmenorrhoea.*

Each case was assessed by history of symptoms and the extent of interference with normal routine stated to have been caused thereby. Cases are classified as follows:

(1) Those who denied any change of normal routine associated with menstruation: (*a*) with no admitted symptoms; (*b*) with symptoms.

(2) Those who stated that they absented themselves from games and social engagements.

(3) Those who stated that they stayed away from work.

TABLE I.

	No. of cases	Percentage
Symptom free	339	47·5
Symptoms		
No change of routine	213	29·8
Absent from games, etc.	54	7·5
Absent from work ...	108	15·1
Total	714	100·0

Of those complaining of symptoms, 50.4 per cent took medical preparations habitually. Only 7.2 per cent had at any time consulted a doctor about dysmenorrhoea.

3. *Relation of Dysmenorrhoea to Age.*

Table II and Fig. 1 show the incidence of dysmenorrhoea in different age groups. The percentage of symptom-free individuals is minimal in the 20–21 age group, and thereafter rises with age. The high incidence of symptom-free individuals over 27 years of age is seen to be statistically significant in the following table, while the

TABLE II.

	Age in years					
	Under 20	20-21	22-24	25-27	28-30	Over 30
Symptom free	45.4	38.9	42.4	43.8	46.3	64.4
Symptoms but no change of routine	35.7	36.1	32.4	35.9	33.3	23.7
Change of routine	18.9	31.0	25.2	20.3	20.4	11.9
Total	100.0	100.0	100.0	100.0	100.0	100.0
No. of cases	185	90	262	64	54	59

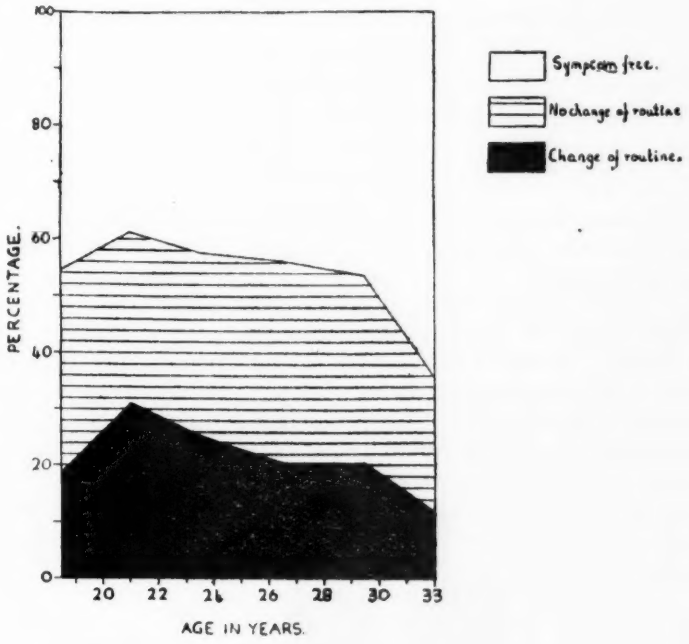

FIG. 1.

Incidence of dysmenorrhoea by age.

2. *Comparison between Recruits and Serving Auxiliaries.*

Not any significant difference was found between recruits and serving auxiliaries as to incidence or severity of dysmenorrhoea.

difference between the Under 20's and 20–27's is not significant.

TABLE III.

Age in years	Percentage symptom free	Difference from age group 20–27	Standard error of difference	Ratio diff.: S.E.
Under 20	45.4	3.6	4.4	0.8
20–27	41.8			
Over 27	55.8	14.0	5.3	2.7

The incidence of interference with normal routine also falls off significantly with age.

TABLE IV.

Age in years	Change of routine free	Difference from age group 20–27	Standard error of difference	Ratio diff.: S.E.
Under 20	18.9	6.8	3.6	1.9
20–27	25.7			
Over 27	15.9	9.8	4.0	2.5

It appears, therefore, that the frequency of dysmenorrhoea decreases gradually with age, and markedly after 27 years. An enquiry into menstruation in schoolgirls carried out by the London Association of the Medical Women's Federation[1] found an increase in frequency of dysmenorrhoea throughout the school age. The percentage of symptom-free girls fell from 72 per cent in the early age groups to 27 per cent in the older groups. An exact comparison with the present inquiry is not possible as the figures are not given by age but by length of menstrual history. Nevertheless, from the pooled results of both these inquiries, it appears that the incidence of dysmenorrhoea rises until the early 20's, and then begins to fall off. This finding also accords with the generally held clinical impression that girls "grow out" of their dysmenorrhoea.

4. *Relation of Dysmenorrhoea to Employment Group.*

At the A.T.S. Training Centres much effort is made to place each recruit in the employment group for which she is best fitted physically, intellectually and temperamentally. Any differences, therefore, between incidence of dysmenorrhoea in different employment groups might be explained either by the nature of the work or by differences within the individuals. A group of 555 Serving Auxiliaries have been analysed with reference to employment as follows:

(1) *Operational.* Anti-Aircraft Command. (*a*) Indoor—Personnel employed on underground signal duties; (*b*) Outdoor—Personnel employed on A.A. gun sites and searchlight sites.

FIG. 2. Incidence of disabling dysmenorrhoea in different employment groups.

(2) *Non-operational.* (*a*) Indoor—Cooks and orderlies, storewomen, clerks and administrative personnel; (*b*) Outdoor—Storewomen and drivers.

Fig. 2 shows the incidence of dysmenorrhoea of sufficient severity to cause change of normal routine in the 4 groups given above.

The lowest rate of dysmenorrhoea is seen to be in the outdoor operational group. Girls selected for this work have to be of a high standard of physical fitness.

Table V compares the incidence of dysmenorrhoea in this group with the mean incidence among the rest, and shows it to be significantly lower.

TABLE V.

Employment	Percentage change of routine
Operational, outdoor	11.7
Rest	26.5
Difference	14.8
Standard error of difference ...	3.6
Ratio difference : S.E.	4.1

The highest incidence of dysmenorrhoea is seen in the indoor operational workers. The difference between this group and the mean of the rest is just significant, being 14 per cent, with a standard error of difference of 7. The auxiliaries in this group, though all employed on similar work, are not all selected in the same way. The group can be divided into 2:

(1) A.A. personnel who have to conform to the physical standards of outdoor operational workers and who may be posted to this type of indoor work, or more commonly to A.A. sites.

(2) Personnel attached to Royal Corps of Signals. These latter need not attain the same high standard of physique and will always work indoors, whether on operational or non-operational duties.

For both groups the work is exacting and trying, particularly so at the time of this inquiry, which was towards the end of the flying bomb period, but owing to a different shift system the latter group have longer hours underground, more disturbed sleep, and appeared to worry about their work a good deal more than the A.A. girls.

The following table shows the number of cases in each section complaining of dysmenorrhoea:

TABLE VI.

	A.A. Percentage	Signals Percentage
No change of routine ...	16 (84.2)	16 (51.6)
Change of routine ...	3 (15.8)	15 (48.4)
Total	19 (100)	31 (100)

It is obvious that it is the signal personnel who contribute largely to the high incidence of dysmenorrhoea amongst indoor operational workers. Comparing these with the rest of the total sample, the following table is obtained:

TABLE VII.

	Percentage change of routine
Signals	48.4
Rest	21.6
Difference	26.8
Standard error of difference ...	9.2
Ratio difference : S.E.	2.9

The A.A. girls employed on indoor signal work have an incidence of dysmenorrhoea of 15.8 per cent. This is not significantly different from the incidence in A.A. girls employed outdoors, which is 11.7 per cent.

A further sub-division of the total sample was made into sedentary and non-sedentary workers.

TABLE VIII.

	Percentage no change of routine	Percentage change of routine
Sedentary workers	73.6 ± 5.6	26.4 ± 5.6
Non-sedentary workers	78.4 ± 4.6	21.6 ± 4.6

There appears to be no difference between these two groups. This section shows that in the studied sample, good physique and general health are associated with freedom from symptoms, whilst anxiety arising from the nature of employment may be a factor in aggravating dysmenorrhoea.

5. *Relation of Dysmenorrhoea to Rank.*

Table IX and Fig. 3 show the incidence of dysmenorrhoea according to rank.

As age is known to have an effect on the incidence of dysmenorrhoea, and the average age of the officers is higher than that of the rest, a correcting factor has been applied to the figures for officers. (For method used, see Section C.2. Relation of amenorrhoea to size of family.) The last column now shows what the rate in officers would be if the age composition of this group were the same as that of the total sample. The incidence of disabling dysmenorrhoea is slightly higher amongst officers than amongst the rest, though not significantly so.

The incidence of complete freedom from symptoms, however, is also highest in the officer group. This discrepancy is intelligible if we assume that officers in giving a history might be more apt to minimise symptoms.

TABLE IX.

	Officers	Cadets and N.C.O's	Privates	Officers corrected for age
Symptom free	57.1	54.1	40.8	57.5
Symptoms but no change of routine	16.7	25.4	37.3	15.1
Change of routine	26.2	20.5	21.9	27.4
Total	100.0	100.0	100.0	100.0

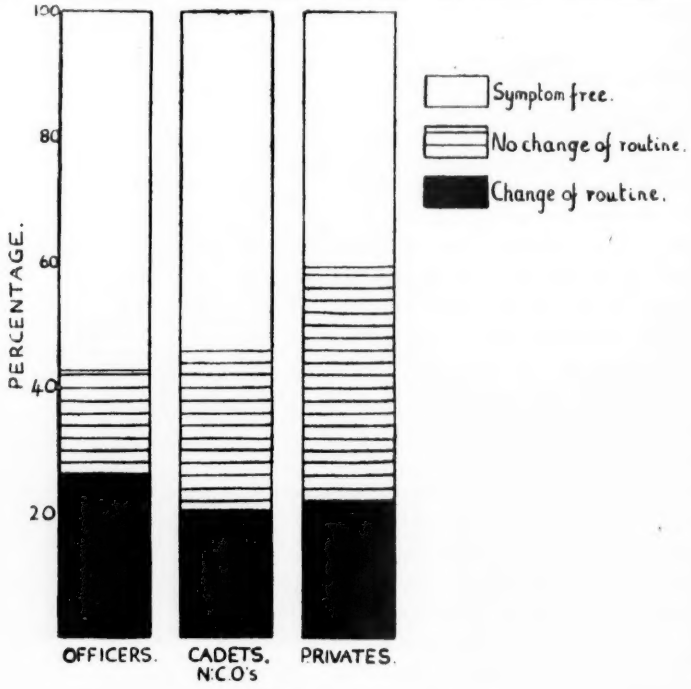

FIG. 3.
Variation in incidence of dysmenorrhoea with rank.

6. *Relation of Dysmenorrhoea to Intelligence-level.*

The selection-grading used in the Service is based on the Raven progressive matrices, which divides personnel into grades 1 to 5, grade 1 being those of highest intelligence. Since January 1942 no women of S.G. 5 have been admitted to the A.T.S., so that the figures in this group are not representative of this class as a whole. Fig. 4 represents the incidence and severity of dysmenorrhoea in the different selection grades.

The S.G. 1 and 2 groups appear to have a higher incidence of alleged freedom from symptoms; however, this is not significant and may be explained by the preponderance of officers in this group. Therefore, if the criterion of dysmenorrhoea is taken to be freedom from symptoms, not any difference is seen between the intelligent grades.

If, however, the criticism is taken to be interference with normal routine, the S.G.'s 4 and 5 appear to have more dysmenorrhoea, as shown in Table X.

TABLE X.

S.G.	Percentage change of routine
1, 2 and 3	19.7
4 and 5	32.3
Difference	12.6
Standard error of difference ...	6.2
Ratio difference : S.E.	2.0

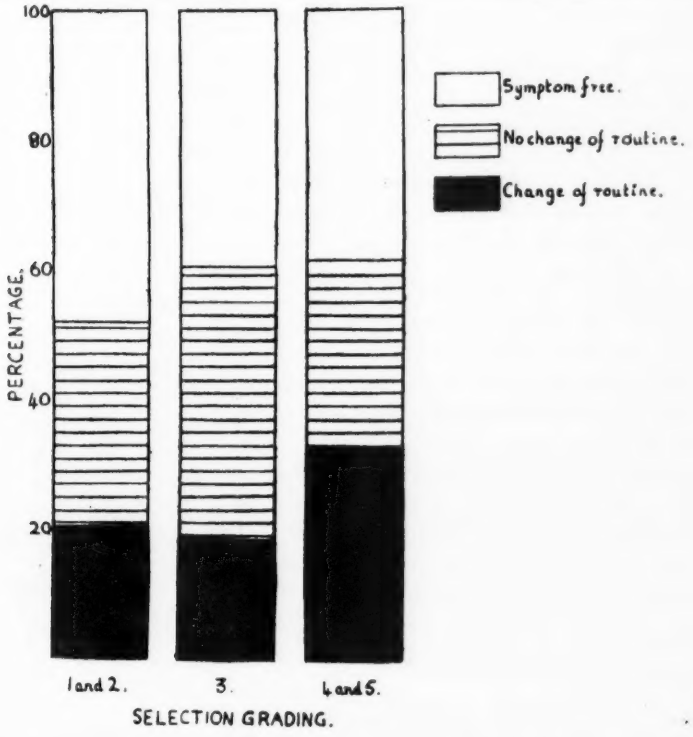

FIG. 4.
Variation in incidence of dysmenorrhoea with selection grading.

It is probable that there is not any real difference in frequency or severity of dysmenorrhoea between intelligence levels; the apparent difference is most likely due to the tendency (familiar to the Regimental Medical Officer) for the lower grades to go off work more readily if they suffer any discomfort.

7. *Relation of Dysmenorrhoea to Size of Family.*

It is popularly supposed that only children are more liable to dysmenorrhoea than those brought up with brothers and sisters. This point was therefore investigated.

TABLE XI.

	Percentage no symptoms	Percentage symptoms	No. of cases
Only children ...	56.0	44.0	91
Rest	46.3	53.8	623
Difference	9.8	—	—
S.E. difference ...	5.6	—	—
Ratio difference : S.E.	1.8	—	—

Only children in this series seem to be less liable to dysmenorrhoea, though the difference is not significant.

In considering the effect of home environment on only children, obviously it will operate more strongly on those who have just left home than in those who have been away from home for some time, living a communal life with large numbers of girls of their own age.

A separate classification was made, therefore, of recruits only, in Table XII, and serving auxiliaries only in Table XIII.

TABLE XII.

Recruits	Percentage symptom-free
Only children	72.0
Others	46.4
Difference	25.6
Standard error of difference ...	11.4
Ratio difference : S.E.	2.2

TABLE XIII.

Serving auxiliaries	Percentage symptom-free
Only children	52.1
Others	47.0
Difference	5.1
Standard error of difference ...	6.1
Ratio difference : S.E.	0.8

Taking recruits separately, there is a significant increase in incidence of symptom-free individuals amongst the only children. Considering serving auxiliaries only, the difference is very small. There is a difference in age distribution of only children among serving auxiliaries, compared with others, but allowing for this variation made very little difference to the original figures. The evidence is, of course, not strong enough to suggest that only children as a whole are less liable to dysmenorrhoea, though it seems certain that they are not more so.

8. *Relation of Dysmenorrhoea to Exercise.*

In the enquiry previously mentioned on menstruation in schoolgirls a positive association was found between freedom from symptoms and exercise. The following table shows incidence of dysmenorrhoea severe enough to interfere with routine, in those who regularly participated in some game or sporting activity, compared with that in those who did not do so. No difference is seen between the two groups.

TABLE XIV.

	Percentage. No change of routine	Percentage change of routine
Exercise	78.6	21.4
No exercise	77.4	22.6

9. *Relation of Dysmenorrhoea to Other Menstrual Phenomena.*

(*a*) *Length of period.* The distribution into short, medium and long periods, with the incidence of dysmenorrhoea in each group, is shown in Tables XV and XVI.

TABLE XV.

Length of period	Percentage
Short: 3 days or less	15.8
Medium: 4 to 6 days	68.6
Long: 7 days or over	16.1
Total: 714 cases	100.0

TABLE XVI.

	Length of period		
	Short	Medium	Long
Percentage:			
No change of routine	80.7	80.0	71.3
Change of routine	19.3	20.0	28.7

There appears to be an increase in dysmenorrhoea in those with a protracted period. There is a difference of 8.8 per cent between the incidence in protracted cases and the mean of the rest. This is just twice its standard error and, therefore, barely significant.

(*b*) *Quantity of flow.* The flow was considered to be scanty when 2 towels or less were the maximum used per day, moderate when 3 to 5 towels were used, and copious when 6 or more towels were used daily. It is realised that women vary considerably in fastidiousness and standards of cleanliness, which influences the number of towels used, but this factor is likely to apply to all groups. In the A.T.S. towels are issued free, and the girl can nearly always obtain as many as she wants.

Tables XVII and XVIII show the distribution of the total sample into these groups and the incidence of dysmenorrhoea in each group.

TABLE XVII.

	Percentage
Scanty flow	15.7
Moderate flow	72.4
Copious flow	11.9

TABLE XVIII.

	Scanty	Moderate	Copious
Percentage:			
No change of routine	83.9	77.1	66.7
Change of routine	16.1	22.9	33.3
Total	100.0	100.0	100.0

The difference assessed by change of routine is 17.2 per cent lower in the scanty than in the copious flow. This is over 3 times its standard error (5.5), and therefore highly significant. It may be that abstention from games and social occasions is due to the copious flow itself and not to dysmenorrhoea; but the clinical impression that short, scanty periods are associated with pain is certainly not borne out here.

(*c*) *Relation of Dysmenorrhoea to Regularity of Cycle.* See section following (B.2).

B. Irregularity of Cycle.

Auxiliaries who stated that they did not know when to expect their next period were deemed to have irregular periods. Of the rest, some may well have experienced variations of a few days. Of the total sample, 16.2 per cent gave a history of irregularity.

1. *Relation of Irregularity to Age.*

The following table shows the age distribution of those giving a history of irregularity:

TABLE XIX.

	Age in years					
	Under 20	20-21	22-24	25-27	28-30	Over 30
Irregularity	15.2	19.8	18.5	14.5	12.8	8.5
No irregularity	84.8	80.2	81.5	85.5	87.2	91.5
Number of cases of irregularity	28	18	48	9	7	5

The incidence of irregularity is compared in 3 age groups in Table XX.

The small incidence in irregularity of cycle in the over 27 age group is only just significant, but the trend is interesting as it is similar to that for the age distribution of dysmenorrhoea, and of amenorrhoea at entry as seen in Fig. 5.

TABLE XX.

Age in years	Percentage irregularity	Difference from age group 20–27	Standard error of difference	Ratio difference : S.E.
Under 20 ...	15.2	3.0	3.2	0.9
20–27	18.2			
Over 27 ...	10.5	7.7	3.9	2.0

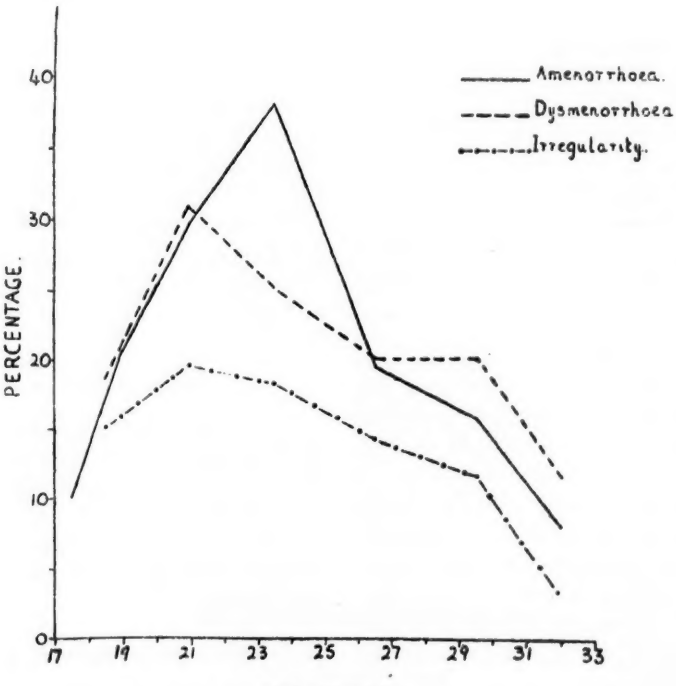

FIG. 5.
Incidence of menstrual disturbances by age.

2. *Relation of Irregularity to Dysmenorrhoea.*

TABLE XXI.

Periods	Percentage: No change of routine	Percentage: Change of routine
Regular	80.3	19.7
Irregular	60.7	39.3
Difference	19.6	
Standard error of difference	4.7	
Ratio difference : S.E. ...	4.2	

There is seen to be a highly significant increase in disabling dysmenorrhoea amongst those with irregular cycles.

C. Menstrual Disorders at Entry to the A.T.S.

The following sections on menstrual disorder immediately following entry to the A.T.S. refer only to serving auxiliaries, as the majority of recruits had been in the Service for under 2 months. The criticism may be put forward that a woman's memory of the past history of her menstrual function is highly inaccurate and that only dates set down at the time are reliable. This is certainly true of the normal function; very few women can remember accurately the dates of past periods that have occurred within what she regards as her normal limits. But if she is normally regular she will remember interruptions in that regularity, especially if associated with a definite event, such as entering the Services. She will remember if she missed one or more periods, if she started or stopped having pain, and if she lost more or less than she had been accustomed to. It is therefore considered that such facts, elicited by questioning even some time afterwards, are reliable and probably represent a very close approximation to actual occurrence and incidence.

Data regarding amenorrhoea and other disturbances at entry, or subsequently during service, were classified as follows:

Amenorrhoea: Cessation of menstruation over a period of longer than 56 days' duration.

A. Minor disturbances lasting less than 56 days.

B. Polymenorrhoea (i.e. increased flow with decreased length of cycle).

C. Irregularity in personnel previously regular.

D. Regular change of rhythm.

E. Dysmenorrhoea in personnel previously symptom free.

F. Menorrhagia (i.e. profuse flow, usually called "flooding" by the auxiliary).

Improvement denotes less dysmenorrhoea and/or irregularity since entry.

Table XXII exhibits the proportions of these categories (*a*) at entry; (*b*) during service.

TABLE XXII.

	(*a*) At entry		(*b*) During service	
	Number of cases	Percentage	Number of cases	Percentage
Amenorrhoea ...	141	25.4	19	3.4
A	11	2.0	3	0.5
B	3	0.6	3	0.5
C	11	2.0	16	2.9
D	23	4.1	14	2.5
E	7	1.3	17	3.1
F	7	1.3	5	0.9
Improvement ...	—	—	53	9.6
No change	352	63.3	425	76.6
Total	555	100.0	555	100.0

No less than 25 per cent of the women questioned stated that they had missed at least one period on entry into the A.T.S. Some other disturbance occurred in 11.3 per cent.

During service amenorrhoea was only reported by 3.4 per cent, nearly always associated with some anxiety or emotional stress. Though figures have not been found for comparison, it seems likely that the incidence of menstrual disturbance recorded during service is no higher than would be expected in ordinary life.

rhoea lasting for longer than 12 months, all resumed the normal cycle spontaneously without recourse to medical treatment, though a few individuals did consult a medical officer. These 3 cases had all received endocrine therapy; when interviewed they were menstruating normally again.

1. *Relation of Amenorrhoea at Entry to Age.*

Tables XXIV and XXV show the age distribution of amenorrhoea at entry.

TABLE XXIII.

	No. of missed periods													
	1	2	3	4	5	6	7	8	9	10	11	12	16	Total
Amenorrhoea at entry	46	26	47	7	4	5	—	2	—	1	—	1	12	141
Amenorrhoea during service ...	7	2	6	2	2									19

TABLE XXIV.

	Age in years							
	Under 18	18-20	20-21	22-24	25-27	28-30	Over 30	Total
Amenorrhoea at entry	10.0	20.8	29.9	38.0	19.6	16.0	8.3	25.4
No amenorrhoea at entry... ...	90.0	79.2	70.1	62.0	80 4	84.0	91.7	74.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. of cases	40	106	194	108	46	25	36	555

TABLE XXV.

Age in years	Percentage amenorrhoea	Difference between successive age groups	Standard error of difference	Ratio difference . S.E.
Under 20	17.8			
20–24	32.8	15.0	4.2	3.6
25–30	18.3	14.5	5.4	2.7
Over 30	8.3	10.0	6.4	1.6

The next table shows the distribution of amenorrhoea lasting for varying periods of time. One missed period indicates about 56 days' cessation of menstruation; 2 missed periods about 84 days, and so on.

With the exception of 3 cases of amenor-

The difference between the age groups shown above are statistically significant in all but the over 30's. Here the numbers are very small, as few women enter the A.T.S. over this age, making the standard error proportionately larger.

2. *Relation of Amenorrhoea to Size of Family.*

The following table shows incidence of amenorrhoea at entry in only children and those with sibs:

TABLE XXVI.

	Percentage amenorrhoea at entry
Only children	37.0
Others	24.0
Difference	13.0
Standard error of difference ...	6.0
Ratio difference : S.E.	2.2

As age is known to have a marked effect on the liability to amenorrhoea at entry, the age composition of the 2 groups were compared. (Table XXVI.)

It is obvious that there is a difference in age composition of only children compared with the others. On the supposition that only children have the same age incidence of amenorrhoea as the total sample, the expected rate in only children with the above age distribution (Table XXVII) would be:

$$\frac{(ai \times aiii) + (bi \times biii) + \ldots\ldots\ldots + (ei \times eiii)}{100} = 28.3$$

Assuming that the others have the same age incidence of amenorrhoea as the total sample, their expected rate with the age distribution shown above would be:

$$\frac{(aii \times aiii) + (bii \times biii) + \ldots\ldots\ldots + (eii \times eiii)}{100} = 25.0$$

The age composition of only children as compared with that of the total sample is, therefore, such as to exaggerate their apparent amenorrhoea rate in the ratio of 28.3 over 25.4. The effect of age can, therefore, be eliminated by multiplying the observed rate—i.e. 37.0 by 25.4 over 28.3, giving a corrected rate of 33.2. In the same way, if age differences were eliminated, the mean incidence in the others would be 25.4 over $25.0 \times 24.0 = 24.4$.

TABLE XXVII.

	Age in years. Under 20 (a)	20-21 (b)	22-24 (c)	25-27 (d)	Over 27 (e)	Mean incidence of amenorrhoea
(1) Percentage age distribution of only children	18.1	41.7	27.8	7.0	5.5	37.0
(2) Percentage age distribution of others	27.1	34.2	18.2	8.5	12.0	24.0
(3) Percentage age incidence of amenorrhoea, total sample	17.8	29.9	38.0	19.6	11.5	25.4

The following table compares these corrected rates:

TABLE XXVIII.

	Mean incidence of amenorrhoea corrected for age
Only children	33.2
Others	24.4
Difference	8.8
Standard error of difference ...	5.9
Ratio difference : S.E.	1.5

The difference is seen to be much reduced and no longer statistically significant.

3. *Relation of Amenorrhoea to Rank.*

The following table shows the incidence of amenorrhoea at entry by rank:

TABLE XXIX.

	Percentage at entry amenorrhoea		No. of Women
Officers	2.4		42
Cadets	21.9	27.4	35
Other ranks	27.9		406

There is no significance in the difference between rate in cadets and other ranks, the difference of 7.0 per cent. being less than its standard error of 7.3 per cent.

However, there is a marked difference between incidence in officers and the rest. The difference is 25 per cent, which is nearly 8 times its standard error (3.3) and highly significant. Again the age distribution must be considered in each group. The expected rate in officers, with the age distribution given, assuming the same age incidence as of the total sample, would be 21.6. Therefore, correcting for age would bring the rate in officers up to 2.7, which leaves the contrast with cadets and other ranks as great as before.

The comparative rarity of amenorrhoea at entry among officers is remarkable in view of the fact that no officer interviewed had received a direct commission; the majority had served in the ranks for at least 1 year. The marked discrepancy between officers and officer-cadets is also interesting. It is probably accounted for by an alteration in the criterion of officers selection during the war. Nearly all the officers interviewed had been commissioned for longer than 2 years, many of them had been to boarding school, university, or into jobs away from home. This was not found to be so amongst the cadets. It is likely that in the case of the officers the transition to a communal life involved less emotional strain, thus accounting for the low incidence of amenorrhoea.

Summary.

A study has been made of normal and abnormal menstrual function in the A.T.S. Auxiliaries, over 700 women from all branches of the Service being interviewed with regard to social and personal background and menstrual history. The following conclusions were reached:

A. *Dysmenorrhoea.*

(1) Nearly 50 per cent did not admit to having symptoms at menstruation. Only in 23 per cent was there any interference with normal routine.

(2) The incidence of dysmenorrhoea is highest in the early twenties, and falls off markedly over 27 years.

(3) A high standard of physique and general health was associated with freedom from symptoms, whilst anxiety resulting from nature of employment appeared to aggravate dysmenorrhoea.

(4) No striking difference was found between the incidence of dysmenorrhoea in officers and other ranks. Inconclusive results were also found when comparing intelligence grades.

(5) Only children were found to have a lower rate of dysmenorrhoea, this being statistically insignificant in those who had been in the Army over 3 months, but significant in those who had recently enlisted.

(6) An increase in dysmenorrhoea was found in those having a protracted period and profuse flow.

B. *Irregularity of Cycle.*

(1) 16 per cent gave a history of irregularity.

(2) Like dysmenorrhoea, irregularity is highest in the early twenties, falling off in subsequent age groups.

(3) There was found to be a highly significant excess in dysmenorrhoea amongst those with irregular cycles.

C. *Menstrual Disorders at Entry to the A.T.S.*

(1) Over 25 per cent of auxiliaries gave a history of one or more missed periods at entry to the A.T.S. 11 per cent suffered some other disturbance.

(2) As with other disturbances studied, incidence of amenorrhoea was highest in the early twenties. Girls entering the A.T.S. in their teens, or over 24 years, have a significantly lower rate.

(3) There was a higher incidence of amenorrhoea at entry in only children, which, however, was not significant.

(4) The rate for amenorrhoea amongst officers was only about one-twelfth that found in other ranks, although all officers interviewed had previously served in the ranks. It is suggested that this large difference can be accounted for by the fact that many officers had previously been away from home at boarding school, University, or in jobs, and therefore the transition to a communal life involved less emotional stress in their case.

My thanks are due to all the A.T.S. Officers and other ranks who co-operated so willingly; to Dr. R. W. Gunderson, late Major, R.A.M.C., for advice on the statistical analysis; to Prof. L. Hogben, F.R.S., Deputy Director Medical (Statistical) Research, War Office, and to Dr. W. Tegner, M.R.C.P., late Lt.-Col. R.A.M.C., under whose supervision the enquiry was carried out, and to Lt.-Col. Albertine Winner, O.B.E., R.A.M.C., who initiated the investigation and for her constant help and encouragement.

REFERENCE.

[1]Report of London Association of the Medical Women's Federation. *Lancet* 1930, ii, 57.

Classification of the Human Pelvis, with a Preliminary Note on the Evolution of the Anthropoid or Ultra-dolichopellic Type of Pelvis.*

BY

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I. INTRODUCTORY NOTE.

MOST systems of classification of the pelvis are obstetrical, and have an aetiological basis. There appears to be no classification by an anatomist. Anatomy in itself, as Bolk[1] pointed out, has no creative power but is entrusted with the function of controlling, a control indeed which morphology cannot dispense with. Morphology is dependent on a consideration of function (physiology) in addition to anatomy—the latter observes, the former explains. The anatomist has pursued his line of thought concerning the pelvis into the more profound region of ontogeny to the exclusion of the simpler consideration of the influence of the bony pelvis on parturition. Therefore, classification of the pelvis has been left to the accoucheur. The latter has attempted quite reasonably to classify the girdle on a pathological basis, having as his first consideration the recognition of the types that cause dystocia. It has been more difficult to identify the morphological characters of the pelvis that are most favourable to labour, that is, to discover what is the ideal female pelvis.

II. VARIOUS CLASSIFICATIONS.

1. Van Deventer,[2] in the first classification of the female pelvis in 1716, recognized 3 types: too large, too small, and too flat. Ingenuous as this grouping may appear, the analytical perspicacity displayed has not been significantly surpassed during the last two-and-a-half centuries. It is unlikely that there will ever be a simple and satisfactory classification of the pelvis, and the types of a given system will be useful for special purposes only. Pelves will, therefore, have to be grouped according to a prescribed purpose so that the basis may be, for example, obstetrical or anthropological.

2. Obstetrical classifications have been concerned with peculiarities, usually of a pathological nature, which give rise to dystocia: the morphology of the normal pelvis and its variations has been disregarded, except for a recognition of the small pelvis with average proportions (justo-minor or generally contracted pelvis). Thus Litzmann's,[3] Kerr's,[4] Williams'[5] and Zangemeister's[6] classifications vary only slightly, and are based on deformities due to (*a*) faulty development, (*b*) disease of the pelvic bones, (*c*) disease of the vertebral column and (*d*) disease of the lower extremities. These classifications are of little interest to the anatomist.

3. It was not until 1933 that a more satis-

* The contents of this paper follow closely Part III of a D.Sc. thesis (1945) presented by the author to the University of the Witwatersrand, and entitled "A Critical Analysis of the Bantu Pelvis, with special Reference to the Female."

factory classification on morphological lines was reported by Caldwell *et al.*[7] Following von Stein's[8] scheme of grouping pelves into round, longitudinal-elliptical, and transversely-elliptical, these workers recognized 4 parent types: (1) the gynaecoid or average female type, (2) the android type with a strong male tendency, (3) the anthropoid type which is longitudinal-elliptical, and which resembles the brim shape of anthropoid apes and to a less extent that of all other mammals, and (4) the platypelloid or transversely-elliptical type. In addition to the parent types there are 6 groups with mixed characters, for example, gynaecoid with anthropoid tendency or android with gynaecoid tendency (see Table I).

Caldwell *et al.*[7, 9] drew attention to the moderate frequency (about 12 per cent) of the anthropoid type pelvis and described its labour mechanism. It is actually their great contribution to labour mechanisms which were studied radiographically in parturients,[10, 11] that has made this team of workers celebrated. This fame has unfortunately spread to their classification which has received universal recognition. The classification is sufficiently complicated to be poorly understood by the majority of its would-be adherents, and its value has only rarely been discussed. In addition to the statement that a pelvis belongs to 1 of the 12 classes seen in Table I, it is necessary to ascertain: (1) whether the forepelvis is narrow, rounded, et cetera, and (2) whether the pubic arch is wide, moderate, or narrow. Such a classification is too cumbersome, having only the merit of describing a pelvis, whereas the rationale of classifying an object is to reduce description by placing the object in a previously defined category. Because the Caldwell and Moloy system is accepted to-day, 167 Bantu dry pelves have been classified accordingly (Table I), and reference will be made to the principles underlying the scheme.

TABLE I.

Bantu Pelves (Caldwell and Moloy Classification). *American-white Figures in Parenthesis.*

Classification	Female: No. of pelves	Female: Percentage incidence	100 male
True anthropoid type	9 (25)	13.4 (11.6)	16
Anthropoid with gynaecoid tendency ...	8 (14)	11.9 (6.5)	2
Gynaecoid with anthropoid tendency ...	4 (10)	6.0 (4.6)	12
Gynaecoid with narrow forepelvis ...	8 (24)	11.9 (11.1)	7
True gynaecoid type	19 (85)	28.4 (39.5)	15
Gynaecoid with flat tendency	4 (7)	6.0 (3.3)	0
True flat (platypelloid) type	1 (2)	1.5 (0.9)	2
Android with anthropoid tendency	4 (8)	6.0 (3.7)	4
Android with gynaecoid tendency	1 (11)	1.5 (5.1)	0
True android type	6 (25)	9.0 (11.6)	39
Android with flat tendency	2 (4)	3.0 (1.8)	2
Asymmetrical forms	1 (4)	1.5 (1.8)	1

To avoid a lengthy exposition of the Caldwell and Moloy classification, it is suggested that the reader who is unacquainted with the system should refer to the authors' diagrams in their 1934 article.[9] It is in this paper also that their ideas concerning the evolution of the pelvis are set out (pages

3, 6 and 7). The classification is based entirely on the nature of the pelvic brim, and more particularly on that part of it lying posterior to the widest transverse diameter of the brim, this segment being only a little different from Derry's posterior segment of the pelvic chilotic line[12] and Straus[13] lower iliac height. In the anthropoid type of pelvis the distance of the transverse diameter from the sacrum is great, in the gynaecoid type intermediate in length, and in the android type the diameter lies close to the sacrum. The anterior half of the brim is also characteristic for the different types, and may give rise to mixed types. This scheme of grouping is followed fairly faithfully by Turner's brim index,[14] making the types mentioned respectively dolicho-, mesati-, and platypellic. There is indeed small merit in applying a new terminology to these pelvic inlets.

Quite apart from the above morphological types, and excluded from the Caldwell and Moloy classification, there occur pathological types in regions where rickets is common, and which may range from antero-posterior flattening to the complete distortion found in osteomalacia.

Comparatively rare pathological and developmental anomalies may cause asymmetry due to faulty posture (disease of spine or lower limbs), or the contraction seen in the Naegele and Robert pelves in which there is faulty development of sacral alae.

III. Caldwell and Moloy Classification of 167 dry Bantu Pelves of both Sexes.

The classification in Table I of Bantu pelves is based on the standard laid down by Caldwell *et al.*[7, 9] whose paper[9] presented a classification of 215 American-white female pelves, the figures relevant to which are here given in brackets after the Bantu figures.

It has been observed that the male pelvis exhibited several of the Caldwell and Moloy types, and an attempt was made to classify the male series according to the scheme for the female. It was surprising to find examples of nearly all the types, and even a male pelvic type which was hardly distinguishable from the essentially female gynaecoid type. In Table I male figures are seen opposite gynaecoid and android divisions: this analysis is recorded for the purpose of comparison, for whilst similarity to these female types does exist in the male, it is not intended to extend the connotation of gynaecoid and android to male pelvic types.

With a few exceptions, the table shows a fairly close correspondence between the 3 sets of figures. The Bantu sex differences *qua* incidence are seen (1) in the android parent type where the difference in favour of the male is 6.6 times its standard error; (2) in the gynaecoid parent type with a difference in favour of the female of 2.33 times its standard error. The higher incidence of true anthropoid types in the male has no statistical significance. Thus in the male series the highest incidence was in the android group, and in the female a high incidence of the same order was found in the gynaecoid group. The European female figures correspond in this respect with the Bantu. Apart from these 2 fundamental sex types, there is an appreciable correspondence between the females of the two races on one hand and the male Bantu on the other.

The true anthropoid type occurs in much the same proportion in both the Bantu and the American-white series. But if this group is taken together with the pelves showing anthropoid tendencies, the Bantu female incidence is 37 per cent (34 per cent for the male), and the white 26 per cent. The difference for the female is 1.5 times its standard error; and for male and female

Bantu combined the difference from the white material is 2.0 times its standard error: significance for this difference has not been established by radiographic studies of 150 Bantu women.

The true gynaecoid type—the nearest approach to what is considered to be the ideal female pelvis—occurs in 28 per cent only of female Bantu pelves as compared with 40 per cent of whites. This might be regarded as possibly significant, were it not for the fact that the gynaecoid type with corresponding tendencies (e.g. anthropoid, flat or narrow forepelvis) occurs with much the same frequency in both female series.

While it was surprising that in the female the true android type actually had a lower incidence (9:12 per cent) in the Bantu than in the white, the difference found is not significant. If all pelves exhibiting android tendencies are grouped together, the Bantu female percentage is found to be 20 as compared with 22 in the American series.

The female types with flat tendency occurring both in the gynaecoid and in the android type show in each case nearly twice the percentage in the Bantu series as in the American. The gynaecoid figure at 6.0 per cent and the android at 3.0 per cent are so low as to lack significance. If this tendency were established in a larger series, it might be suggested that the underlying cause is associated with some factor such as rickets which is so prominent during Bantu childhood.

The purely asymmetrical forms shown could not readily be subclassified. Where asymmetry occurred in pelves of other types, an alternative diagnosis was made.

IV. Evolution of the Human Pelvis: Criticism of Caldwell and Moloy's View.

Caldwell *et al.*[9] have ventured beyond their classification in an attempt to explain the origin of the parent types. In this paper their ideas are illustrated diagrammatically, and in the printed paragraph beneath the figure it will be seen that the authors refer to their belief in an evolutionary factor which is responsible for producing the typically platypellic human forms ranging orthogenetically from extreme dolichopelly to an ultra-human platypelloid human type. In the same paper they claim that this hypothesis is the most important contribution of their work.

The Caldwell and Moloy view is that orthogenesis begins in lower mammals where the pelvic inlet is always longest in the anteroposterior axis (brim index over 100), and ends with platypelly found in in man (brim index under 100). The authors assert that the occurrence of anthropoid type pelves (10 to 20 per cent) is due to an arrest of evolution.[9] These assertions will now be examined.

If the recapitulation theory is being invoked for the argument concerning the arrest of evolution there is a danger that evolution, or this process of "arrest in evolution," might be by-passing the foetus in respect to the pelvis. If the Caldwell and Moloy hypothesis is to mean anything, the picture before one is a high incidence of primitive "anthropoid type" pelves in the foetus and embryo; a more human (possibly flattish) pelvis later during ontogeny; and at the end of ontogeny some more highly developed pelvis which is well removed from the ape (or lower mammalian) pelvis morphologically. Our authors choose to believe that this last, fully evolved, pelvis is their platypelloid type, i.e. a pelvis with an average brim index below 80. This presumption is based on very poor evidence, for not only have Caldwell and Moloy[9] reported an incidence of only 2 per cent for this type, but the Bantu incidence does not rise above this figure, nor does the English (Ince and Young,[15] Kenny[16]). Moreover, Caldwell

and Moloy have made no reference to any personal experience with foetal pelves, nor has any reliable pelvic work been reported by any writer in English. Kappers' monograph[17] is the only available study of this kind which can be considered authoritative.

An ontogenetic survey of the Bantu pelvic brim demonstrates the following facts.

1. Seventeen of 100 foetuses had an index over 100 (or 100 and over). 33 per cent were dolichopellic (index over 95).

2. In 39 children aged 1 to 15 years. 15.4 per cent have indices over 100 and are of well-marked anthropoid type. But 35.9 per cent (14 pelves) have an index of 95 or more.

3.(*a*) In 45 adolescent females aged 15 to 19 years, 13.3 per cent had indices of 100 or 100 and over, and 28.9 per cent were dolichopellic.

(*b*) Of 31 females aged 20 to 25 years, 19.3 per cent had indices of 100 or more, and by some chance 48.4 per cent were dolichopellic.

(*c*) For adult indices of 100 or over, there were 17 of 100 male dry pelves, 12 per cent of 67 female dry pelves, 17 of 100 female X-rayed subjects, and 20 per cent of another series of 25 X-rayed women. The dry pelves exhibited the Caldwell and Moloy anthropoid type in 13.4 per cent of females and 16 per cent of males, both figures being very close to those given above (12 and 17 respectively).

Concerning the foetal brims mentioned under (1) above, the index reached 110 on only 2 occasions, and the brims never resembled the pronounced "anthropoid type" seen in the adult: they certainly do not approach the relative proportions of the ape brim. These high-index foetal brims are, in fact, only round, or "more round" than the average brim.

The infant and child pelvis moves further in the direction of "roundness" than the foetal with a percentage difference which is 2.23 times its standard error. Now for the first time do outspoken "anthropoid types" appear—but the outstanding observation concerning the infant brim is the trend from flatness to roundness.

The percentage difference of indices 100 or over between the 1 to 15 and 15 to 19 year age groups is 2.5 times its standard error, and is probably significant. It is seen, therefore, that from infancy to puberty or thereabouts pelves are significantly less flat than those in the foetus on the one hand and those in the adolescent on the other. The figures for this adolescent period show no significant difference from the total figures for the age period 15 to 25 years; nor do the figures for the 15 to 25-year period differ significantly from the corresponding figures for the adult skeletal material.

The difference in the incidence of dolichopelly in the 15 to 19 and 20 to 25-year age groups is only 1.7 times its standard error, and is not significant. Similarly, the difference in the dolichopellic incidence between the foetal and the 20 to 25-year groups is only 1.5 times its standard error. Adult and foetal incidence of this character correspond closely, being respectively 34.5 and 33 per cent; and the adult dolichopellic incidence is equally similar to that of the 15 to 25-year age group.

In the adult there occurs, on the average, a flatter pelvis than in the child. The "anthropoid type" incidence is still equal to that in the foetus, though the "anthropoid" appearance reaches greater emphasis in the specimens so characterized. Something happens at pubertal age to arrest the development of round or ultra-dolichopellic brims, but the basis of this is not evolution. The cause may be some combination of factors concerned with sex hormones, the influence of nutrition on metabolism, and

physical forces based on weight-bearing and progression.

There is no question here, as Hooton[18] mischievously puts it, of running with the Lamarckian hare and hunting with the Weismann hounds. The possibility under consideration is whether orthogenesis is being exhibited in the case of the pelvis, for on this matter Caldwell and Moloy speak of an arrest in evolution. A point is, therefore, reached at which it appears that many dolichopellic forms, slight and exaggerated, should occur; but coincident in time there emerges the sex factor, and the adolescent phase is associated with only occasional development of the sort of pelvic brim which is found throughout the mammalian class. In the anthropoids, on account of their greater facial angle, the foetal head is held in flexion during labour and thus requires adequate width further forward in the pelvis than is necessary in, say, ungulates.

It is a point of no mean importance that Kenny's[16] paper has established finally the belief that the pithecoid ("anthropoid") type pelvis in women is associated with a minimum of dystocia, complicated labour being much rarer than with the "gynaecoid" pelvis. If labour in mammals be considered, it is not unreasonable to conclude that difficult labour may jeopardise the continuation of the species. Hence only pelves favourable to easy expulsion of the foetus would evolve. In the anthropoid apes greater and rounder heads have developed, and the problem becomes more acute. Observations in *homo sapiens* have demonstrated that the flatter the pelvis, the more difficult does parturition become. Antero-posterior shortening in morphological types is very rare, but common in diseases causing softening of bone. Evidence is accumulating[16] that human types of superior physical status possess on the average round brims, while showing a high incidence of "anthropoid" types. There is mathematical certainty in the fact that, with a given perimeter such as is represented by the brim, a circle encloses the greatest area: as the circumference becomes compressed and alters shape, so there is a loss of area.

So far, then, from supposing that evolution strives for platypelly, the evidence is in favour of dolichopelly being the highest and most efficient attainment. Bolk,[1, 19, 20, 21] in his hypothesis on retardation and foetalisation, has shown that morphologically the apes have advanced much further than man along the road of evolution. His idea was that human anatomical features are all tainted with foetal characteristics; and what represents only a transitional stage in apes, has in man become the consummation of ontogeny. All human races have not made equal progress on the developmental road, and Bolk mentions such examples as the Mongolian physiognomy which is a foetalisation effect absent in white races, and the persistence of a metopic suture which is much more frequent in white than in black races. Bolk emphasizes the necessity for embryonic potentialities in human tissues such as epiphyses which continue to grow over a very long period: phylogenetic maturity could be reached only very late, while retardation during ontogeny is inhibiting this evolutionary progress all the time. This inhibition is often essential for man (*vide* the late obliteration of cranial sutures).

In the pelvis the same process with side effects occurs. During ontogeny (5th to 10th years), attempts at evolving the dolichopellic ancestral pelvis are seen. These attempts appear to be suppressed at puberty; but a certain number of girdles, nevertheless break the bonds of the foetalising influence and become "anthropoid." The majority, however, now resemble the

foetus more closely than they did during infancy.

Although the factors which, in groups such as those studied by Thoms,[22] make possible a pelvic development beyond the foetal stage are unknown, the available evidence contradicts the Caldwell *et al.* belief that the ultra-dolichopellic pelvis represents an arrest in an evolutionary movement which has platypelly as its purpose. There is no evidence for this ill-conceived viewpoint; and it is submitted that in one sense the reverse is true, namely, that the ape pelvis has developed further than man's which is foetal in character, though the latter shows a tendency to reach towards more efficient dolichopelly. If the foetus exhibited many well-developed "anthropoid" forms, and if during adolescence these forms diminished in number and essential characters leaving only a few "evolutionary arrests," Caldwell and Moloy would have gained their point. Unfortunately, the facts are inconsistent with their thesis.

Commentary.

The view of Caldwell *et al.*[9] that the platypelloid pelvis is the end-point of evolution in man, while dolichopelly (resembling the apes) demonstrates an arrest in evolution, has been refuted. Although only Bantu data were used for this argument, it must be stated that the figures of other observers provide equal support. Thus Kappers[17] had only 4 per cent of foetuses with brim index of over 100, and Turquet's series[23] of 70 infantile pelves showed a brim index of 100 or more in 28.5 per cent. Preservation of these juvenile specimens has the effect of raising the index, with the result that the childhood period of ontogeny has always been credited with a very high dolichopellic incidence. Evidence gained from fresh pelves, however, shows that this observation is sound, and the Bantu X-ray results support it strongly.

The view advanced here is that the evolutionary purpose in man is to produce the "anthropoid type" pelvis. In accordance with Bolk's hypothesis, the retardation of the factors leading to pelvic maturity is sufficiently effective to leave the stamp of foetalization on the majority of adult pelves: a minority only excel, become phylogenetically more highly evolved, and are more efficient as ultra-dolichopellic pelves. The latter have relatively larger inlets, presumably because ilium and pubis grow more, in order to provide the long inlet which would have possessed a smaller area had it been round because of the earlier cessation of growth.

To classify pelves until more is known about their evolution is futile. Further ontogenic studies must be directed to X-ray investigation of many pelves during puberty and adolescence in an attempt to determine the factors responsible for development or arrest of the fully evolved human pelvis. Some knowledge of other primate foetal pelves is also necessary (Bolk[24] in 1926 published a paper on the comparative anatomy of a gorilla and a chimpanzee foetus, but this study is not available in South Africa.) The brim index is a promising basis for classification, but it may be necessary to consider other features of which the most significant appears at present to be the pubic arch. Turner's index is, therefore, still the most important determination as a basis for classification. A further observation is found in the fact that a pelvis may be small, average, or large in size; and for parturition this character of absolute size is an essential feature. Pathological anomalies must be considered in a category which bears no relation whatever to morphology. When the ontogenetic investigation now in progress in the Department of Obstetrics has

been pursued further, and the relative capacity of dolichopellic girdles has been determined accurately, a scientific classification may be evolved.

Results.

1. *Mean values of ilium/pubes index.*

50 adult female	100.92	
40 adult male	103.30	
90 combined adult	102.39	Adult
39 age 15–19 years	82.92	Adolescent
43 age 1–15 years	89.34	Child

(*a*) No significant difference was found between males and females of the Adult group, and for statistical purposes the combined group was used.

(*b*) The difference for the means of the Adolescent and Childhood groups was 6.42 ± 2.66, the difference being 2.41 times the standard error and, therefore, probably significant.

(*c*) When compared with the Adult mean, both the Adolescent and Childhood means reveal a difference which is highly significant.

Adult and Adolescent—Difference = 19.47 ± 1.935
= 10.05 × st. error

Adult and Child —Difference = 13.05 ± 2.42
= 5.39 × st. error

2. *Percentage incidence of indices* 100 *and over.*

It was found that only 2 adolescent pelves had an index of 100 or over, and 9 childhood pelves. In the adult, 29 out of 40 (72.5 per cent) males had the index 100 or over and the corresponding figures for the female were 32 out of 50 (64 per cent). This difference is seen reflected in the mean values above, and signifies greater length of the pubic portion of the iliopectineal line before the age of 20 years, and greater length of the iliac portion in the adult.

Significance for these variations, in addition to the results under 1 *a*, *b*, *c*, was found by considering the percentage of the 100 plus against the 100 minus incidence.

(*a*) No significance was found for the difference in the male and female Adult incidence.

(*b*) The percentage difference between the Adolescent and Child groups was 18.5 ± 7.45, which is 2.48 times its standard error.

(*c*) The percentage differences between either the Adolescent or Child groups on the one hand and the Adult on the other are highly significant.

Adult and Adolescent—Difference = 63.2 ± 5.87
= 10.78 × st. error

Adult and Child —Difference = 44.7 ± 8.34
= 5.36 × st. error

Conclusion.

In the respective results under *b* and *c* of 1 and 2, a remarkably close correspondence is found. That is, when the differences between the figures for means are compared on the basis of the standard deviations, the same order of significance is found as when the percentages of indices over 100 and under 100 are compared. The close correspondence suggests that the adult tendency is not only to have a higher index than in individuals under 20, but in fact to be over 100 when the latter are characteristically under 100.

This would mean that up to the age of 20 the pubes is longer than the ilium on the iliopectineal line, and in the adult the ilium is the longer. There are two possibilities for this pronounced difference between the adult and the growing individual.

(1) There may be an unforeseen technical reason, for the adult pelves are all taken from skeletal material, the other groups being derived from radiographic series of living individuals. At present there is not available a series of unselected adult radiographs for the sake of comparison.

(2) If, as is indicated by the figures,

there is this pronounced difference between adult and growing pelvis, it must be accepted that by the time adult age is reached the iliac portion of the iliopectineal line has outgrown the pubic portion, for up to the age of 20 years the pubic portion preponderates.

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APPENDIX

An unexpected finding has emerged from a consideration in the Bantu of the index based on the respective lengths of ilium and pubes which contribute to the iliopectineal line. Both lengths were measured in a straight line from point to point, that is, as chords, not arcs, of a circle. The pubic length was measured from the symphysis to the antero-inferior edge of the Y-shaped cartilage on the iliopectineal line, and the iliac length from the antero-superior edge of the cartilage to the sacro-iliac joint at its junction with the iliopectineal line. This form of measurement was carried out on radiographs from 39 male and female children aged 1 to 15 years and 43 females aged 15 to 19 years. In the latter group the Y-shaped cartilage is rarely seen on the film, but a fairly accurate method of locating it was adopted. In the adult 50 female and 40 male dry pelves were used for the measurement.

A Nutritional Survey among Pregnant Women

BY

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THE "nutritional state of the nation" has been a matter of grave concern to the politician, to the scientist, and to the doctor, during the period of war and its aftermath. Feelings both of anxiety and of assurance have been expressed in numerous pronouncements and editorial comments of lay and medical press; but a final conclusion has not been—nor is likely to be—possible as to whether the British public suffered any serious impairment of health as a result of their restricted dietary during the years of the emergency. The Medical Research Council's Report[1] of its very comprehensive survey of haemoglobin levels left little room for pessimism. The levels found in the blood of all classes studied compared favourably with what figures were available of pre-war haemoglobin percentages; and a study of weights and haemoglobin levels of several thousand women in munition factories (Davies, Gunson, Matheson and Pike[2]) revealed few abnormalities. But against these and other scientific demonstrations of an absence of any departure from commonly accepted ranges of physiological normality, there is a widespread conviction that not only the frustrations and inhibitions of the last 6 years, but also a lack of still undiscovered or improperly understood dietary factors from the restricted and monotonous war diet, may be the root cause of the susceptibility to minor complaints, such as winter colds, often developing into something more serious, which is alleged to exist.

If nutritional deficiencies do, in fact, exist—or have existed during the worst of the war years—it might be expected to find them most pronounced among pregnant women, where the drain from the physiological economy of the mother is severe under ordinary conditions of proper nourishment and replacement, and may result in demonstrable deficiencies where the essential mineral elements and vitamins, and even the more ordinary non-accessory food factors such as proteins, may be in short supply. Hamilton and Wright[3] concluded, from a study of haemoglobin levels and a comparison with other published figures, that women of the artisan class were more anaemic than before the war. Craig and Lewis[4] found a wide variation in the vitamin C saturation of pregnant women, and concluded that it was definitely on the low side. Protein levels in the plasma have been studied by Dyson[1] as part of the Medical Research Council's survey, but demonstrable departures from the range of accepted normal values have been seen only in such severe cases of starvation as those described by Vaughan, Dent, and Pitt Rivers[5] in the concentration camp at Belsen, and by Walter, Rossiter and Lehman[6] among prisoners of war released from Japanese prison camps.

The present investigation was undertaken in 1943 to determine if any evidence of malnourishment could be detected amongst the women of the Hammersmith district attending the prenatal clinic of this

hospital during the course of their pregnancies. Besides the usual careful clinical examination, the subjects were investigated chemically for the ascorbic acid and haemoglobin contents of their blood, and for the alkaline phosphatase activity of their plasma. It is well known that this enzyme accumulates in the blood of cases suffering from generalized bone disease, such as Paget's and von Recklinghausen's, and in the deficiency diseases of rickets, craniotabes and osteomalacia. Indeed it seemed the most promising means of investigating the possibility of abnormality in calcium—phosphorus metabolism, arising either through lack of the minerals or of vitamin D. Estimations of calcium and phosphorus were not undertaken because there is too little evidence that abnormal figures would be encountered in any other than cases of very severe malnutrition, and these we did not expect to find. Estimations of the urinary output of vitamin B_1 were undertaken even though there seemed considerable doubt, in view of the high content of aneurin in the National loaf, as to whether any deficiency might be expected: the results were inconclusive and have been published elsewhere (Simmons and Wootton[7]). This communication, therefore, is concerned with reporting the findings in respect of haemoglobin, vitamin C, and plasma phosphatase in a group of women during the course of their pregnancies, and subsequently, during 1943 to 1945.

Procedure.

At this clinic, women wishing to book for their confinement in hospital report on one of two afternoons in the week. One of the research team was present on each of these afternoons, and 4 women were selected to take part in the investigation. On any one afternoon the first 4 women were chosen, whose duration of pregnancy (judged on clinical grounds) fell within the required limit. Only patients less than 24 weeks pregnant were accepted; the majority were less than 18 weeks pregnant.

This technique of selection was designed to effect random sampling of the population in question. It must be noted that this does not necessarily conform to the general population of the area. Since the patients are those who wished to have their babies in hospital, it is likely that the population is weighted in favour of primigravidae; and also there is probably a relatively high proportion of women who have had previous obstetric complications.

Two samples of blood were required for the biochemical estimations. About 10 ml. of venous blood were oxalated and used for the determination of plasma ascorbic acid and plasma alkaline phosphatase. These determinations were carried out within an hour of the collection. For haemoglobin estimation, 0.05 ml. of blood obtained by ear puncture.

In a certain number of the cases, urinary excretion of aneurin was investigated. These results have already been reported.

The first specimens were taken at the end of the routine examination, during the initial visit of the women to the hospital. At the same time, a special note was made on the patient's history sheet to assist in tracing the patient throughout the pregnancy.

The second specimens were obtained from the same women during another routine visit between the 32nd week and term, usually about the 36th week. The third specimens were taken while the patients were in hospital during the first 10 days of the puerperium.

Between 6 and 12 months after the birth of her baby, each woman was sent a letter, requesting an attendance at the hospital, when the final specimens were taken.

A completed case was, therefore, investigated on 4 separate occasions, but for

various reasons it was impossible to complete a number of the cases. A few of the selected women aborted, whilst others were evacuated to other hospitals to avoid the dangers of enemy air activity. Response to the letters was in some ways discouraging. Much of this work was done during the period of the flying-bomb attacks, and as a result, many women had changed their addresses and could not be traced. Thus, unavoidably, a number of the cases, which had had the first one or two investigations done, could not be followed up. It was decided to include these cases in the survey, thus utilizing all the available data. The number of cases included at each stage of pregnancy therefore varies, but this is not considered a disadvantage, and allowance for it is made in the analysis.

During their attendance at the clinic, a number of the patients were interviewed by the Almoner's staff. The family income from all sources was assessed as accurately as possible. This was divided by the number in the family, and an estimate made of the income per head, with the object of discovering the effect, if any, of income upon the nutritional state.

Biochemical Methods.

(1) *Haemoglobin.* The alkaline haematin method of Clegg and King[8] was employed, all readings being made on the photoelectric colorimeter, against a standard prepared from crystalline haemin. The reasons for considering this method superior to the Haldane estimation are outlined in that paper.

(2) *Plasma ascorbic acid.* Method of Farmer and Abt[9] depending on the titration of a deproteinised filtrate with 2 : 6-dichlorophenolindophenol. More modern methods are more specific but we prefer it for the reasons expressed by Fleming and Sandford.[10]

(3) *Plasma phosphatase.* Estimated as King and Armstrong units by the modified method of King *et al.*[11] Disodium phenyl phosphate is hydrolysed under controlled conditions, and the liberated phenol estimated by photoelectric colorimetry. The unit is the amount of enzyme capable of producing 1 mg. of free phenol under the standard conditions.

Results.

For the sake of brevity, the groups of patients at the different stages of pregnancy have been labelled as follows:

0–24 weeks:	Group A.
32 weeks–term:	Group B.
Immediate puerperium:	Group C.
6–12 months postpartum:	Group D.

In the analysis of results the 1 per cent level has in all cases been taken as the criterion of significance.

Haemoglobin results. The frequency distributions, means and deviations are set out in Table I. In order to facilitate comparison with the results of other investigators, the equivalent percentage on the Haldane scale is inserted in parenthesis, using the conversion factor evaluated by King, Gilchrist and Matheson.[12].

The mean haemoglobin falls from 12.3 g. 82.8 per cent) in early pregnancy to 11.6 g. (78.6 per cent) in late pregnancy. In the puerperium, the mean haemoglobin has almost regained the former value, and a still higher value of 13.1 g. (88.6) is reached in the postpartum subjects. Analysis of the variance demonstrates that these changes are highly significant.

	Within groups	Between groups	z.
Variance	89.32	1768.69	1.49
Degrees of freedom	643	3	

TABLE I.

Haemoglobin Frequency Distributions in the Four Groups.

Haemoglobin	Frequency			
g. Haemoglobin	Group A	Group B	Group C	Group D
6.4– 7.0	.	2 = 0.9%		
7.1– 7.8	.	2 0.9		
7.9– 8.6	4 = 1.5%	1 0.5	3 = 3.2%	
8.7– 9.4	3 1.2	7 3.2	4 4.2	
9.5–10.1	17 6.5	17 7.8	5 5.3	1 = 1.4%
10.2–10.9	22 8.4	34 15.5	6 6.4	3 4.1
11.0–11.7	40 15.3	57 26.0	24 25.6	4 5.5
11.8–12.5	68 26.0	48 21.9	18 19.1	12 16.4
12.6–13.2	48 18.4	28 12.8	12 12.8	23 31.5
13.3–14.0	39 14.9	14 6.4	10 10.6	16 21.9
14.1–14.7	12 4.6	6 2.7	6 6.4	10 13.7
14.8–15.6	5 1.9	2 0.9	5 5.3	3 4.1
15.7–16.4	2 0.8	1 0.5		1 1.4
16.5–17.2				
17.3–18.0	1 0.4		1 1.1	
Total No. of cases	261	219	94	73
Mean	12.3	11.6	12.1	13.1
Standard deviation	1.47	1.44	1.75	1.20

In general these figures are similar to those found by previous investigators (Strauss and Castle,[13] Widdowson,[14] Hamilton and Wright[3]). The drop in haemoglobin during the advance of pregnancy is usually attributed to a "physiological hydraemia," but it has long been uncertain how much of the fall is in fact caused by a deficiency in dietary iron. The difference in haemoglobin between Group A and Group B is less than that found in most previous surveys,[1] but the resting, or non-pregnant haemoglobin level of 13.1 g. (88.6 per cent) is lower than the Price-Jones figure of 98 ± 10 per cent for normal women. Since it appears likely that the blood-volume returns to normal fairly quickly, this suggests that there is a certain amount of iron deficiency.

Plasma Ascorbic Acid. The changes in mean levels as given in Table II have been examined by analysis of variance.

	Within groups	Between groups	z.
Variance	0.0591	1.3578	1.56
Degrees of freedom	619	3	

These differences are significant.

Widely differing values are given by various workers for the mean plasma ascorbic acid during pregnancy. The discrepancies are probably due to two main factors; firstly, the differing methods of estimation used and secondly, the different plasma levels shown by communities with various ascorbic acid intakes. The work of

TABLE II.
Ascorbic Acid Frequency Distributions.

Ascorbic acid (mg./100 ml. plasma)	Frequency			
	Group A	Group B	Group C	Group D
0.10–0.20	4= 1.5%	.		
0.21–0.30	13 5.1	15= 7.2%	7= 7.8%	4= 5.7%
0.31–0.40	45 17.6	41 19.8	26 28.9	5 7.1
0.41–0.50	44 17.2	37 17.8	24 26.7	6 8.6
0.51–0.60	48 18.7	32 15.5	11 12.2	5 7.1
0.61–0.70	31 12.1	21 10.3	11 12.2	13 18.6
0.71–0.80	20 7.8	27 13.0	5 5.6	9 12.8
0.81–0.90	20 7.8	15 7.2	4 4.4	6 8.6
0.91–1.00	12 4.7	13 6.3	1 1.1	6 8.6
1.01–1.10	9 3.5	3 1.5	1 1.1	5 7.1
1.11–1.20	7 2.7	3 1.5		2 2.9
1.21–1.30	3 1.2	.		2 2.9
1.31–1.40				1 1.4
1.41–1.50				2 2.9
1.51–1.60				1 1.4
1.61–1.70				1 1.4
1.71–1.80				1 1.4
1.81–1.90				
1.91–2.00				1 1.4
Total No. of cases	256	207	90	70
Mean	0.59	0.57	0.49	0.80
Standard deviation	0.24	0.22	0.17	0.36

Prunty and Vass[15] shows that the plasma ascorbic acid may be taken as a reliable index of the nutritional state with regard to this vitamin. They found a close correlation between the plasma levels and the results of saturation tests, and concluded that 0.8 mg./100 ml. corresponds with a state of saturation, while normally the plasma level should not be less than 0.4 mg./100 ml.

Camara and Concepcion[16] found the mean plasma ascorbic acid was 0.87 mg./100 ml. of plasma and could not detect any significant difference as pregnancy advanced. They suggest that the Filipinos whom they investigated, live on a diet particularly well provided with ascorbic acid. A comparatively large fall was found by Snelling and Jackson,[17] from 0.6 mg. during the first five months of pregnancy to 0.23 mg./100 ml. in the immediate puerperium. The latter figures show deficiency according to the standards of Prunty and Vass, but possibly some of the difference may be explained by the method of estimation used by Snelling and Jackson.

Other investigations (Teel *et al*,[18] Javert and Stander[19]) have provided results which lie between these extremes, and more in accord with the figures of the present investigation. The possibility that this fall is caused by minor degrees of deficiency cannot be discounted. It is supported by

the findings of Craig *et al*[4] who noticed a wide variation in the results of saturation tests done on pregnant women.

Plasma phosphatase. During the tabulation of these results it was noticed that in addition to the values which might be considered normal in character, there existed a small residuum of 'abnormal' values. These comprised, in the different groups, about 1–4 per cent of the total number of estimations, and were in all cases grossly higher than the maximum to be expected on the grounds of the other 96–99 per cent. These results have been placed in a separate category, and have not been taken into account during calculation of means and deviations. (See Table III.)

The rise during pregnancy, from 4.3 units in Group A (which is normal for non-pregnant women) to about 10 units in Groups B and C, is parallelled by the findings previously published (Cayla and Fabre,[20] Vermehren,[21] Kerleau and Cayla[22]). Exact comparisons are im-

TABLE III.

Phosphatase Frequency Distributions.

Phosphatase	Frequency			
(Units/100 ml.)	Group A	Group B	Group C	Group D
1.1– 2.0	8= 3.1%			
2.1– 3.0	51 19.6			1= 1.3%
3.1– 4.0	66 25.4	1= 0.5%	1= 1.0%	4 5.3
4.1– 5.0	67 25.7	4 1.8	3 3.1	5 6.6
5.1– 6.0	39 14.9	10 4.5	5 5.2	12 15.8
6.1– 7.0	14 5.4	7 3.2	4 4.1	14 18.4
7.1– 8.0	7 2.7	21 9.6	11 11.3	13 17.1
8.1– 9.0	4 1.5	27 12.6	11 11.3	6 7.9
9.1–10.0	1 0.4	26 11.8	16 16.5	6 7.9
10.1–11.0		15 6.8	7 7.2	5 6.6
11.1–12.0		27 12.6	11 11.3	7 9.2
12.1–13.0		21 9.6	7 7.2	
13.1–14.0		18 8.2	5 5.2	
14.1–15.0		8 3.6	4 4.1	2 2.6
15.1–16.0		11 5.0		
16.1–17.0		7 3.2	2 2.1	
17.1–18.0		3 1.4	3 3.1	
18.1–19.0		1 0.5	3 3.1	
19.1–20.0		4 1.8	1 1.0	
>10.0	4= 1.5%			
>20.0		9= 4.1%	3= 3.1%	1= 1.3%
Total No. of cases	261	220	97	76
Mean	4.3	10.5	10.4	7.6
Standard deviation	2.0	3.0	3.5	2.5

possible, owing to the differing units of phosphatase activity. Several explanations have been advanced for this increase during pregnancy. Ramsay *et al*[23] found significantly higher phosphatase values in "ill" patients than in "well", and suggest that there is evidence of unsatisfactory calcium and phosphorus metabolism among the "ill" patients.

Bodansky[24] thought that occasional high values might be due to increased parathyroid stimulation. High values were also found by Ebbs and Scott,[25] but they considered that these were mostly found in cases of twin pregnancy. This has not been substantiated in the present series. Five cases of twin pregnancy have been examined, their average phosphatase considered in Group B is 13.3 units.

It appears to us that both the above workers have, in fact, found examples of this class of abnormally high phosphatase levels. Follow-up of these cases already indicates a relationship with deficient calcium metabolism and infantile rickets. It is hoped to report these results more fully in a later paper.

Correlations. From among the large number of possible correlations, it was decided to select those which would help to answer two questions. Firstly, how far does the value of haemoglobin, plasma ascorbic acid or plasma phosphatase found in Group A enable a forecast to be made of the corresponding value in Group B? Also, does the possession of a low haemoglobin or plasma ascorbic acid, or of a high phosphatase, imply that the other biochemical indices will also be abnormal?

Correlations were calculated between the corresponding values in Groups A and B, and, in Group A, between the three estimations taken in pairs.

These results indicate that only in the case of haemoglobin, can the result in late pregnancy be forecast from early pregnancy. Also, no evidence exists of any state of general nutritional deficiency in the population under consideration.

TABLE IV.

Correlation: Same patients in Group A and Group B.

Estimations	r	n	P
Haemoglobins	0.39	196	<0.01
Ascorbic acids	0.05	184	>0.1
Phosphatases	0.19	184	0.05>P>0.02

TABLE V.

Correlation: Group A patients—2 Estimations.

Estimations	r	n	P
Haemoglobin—Ascorbic acid	−0.13	247	>0.1
Ascorbic acid—Phosphatase	−0.11	248	>0.1
Phosphatase—Haemoglobin	0.07	248	>0.1

Nutritional Status and Income-Level. The original grading of the income-levels by the Almoner's staff divided the patients into three grades. Weekly income per head: (1) more than £1; (2) 10 shillings to £1; (3) less than 10 shillings.

It was found that only a very few patients fell within the grade whose weekly income was less than 10 shillings per head. The latter 2 grades were therefore combined, so that in Grade R the weekly income per head was more than £1 and in Grade P the weekly income per head was less than £1. The mean levels for the two grades are set out in Table VI. The figure in parenthesis indicates the number of cases from which the average is derived.

The mean levels are a sufficient indication that in this survey income level has apparently no bearing on the nutritional state. This is in agreement with the findings of Boycott,[26] though Reid and Mackintosh[27, 28] showed that the incidence of anaemia could be correlated with the social status. It must be noted that in the present

TABLE VI.
Variation with Income Level.

	Group A	Group B	Group C	Group D
Haemoglobin Mean				
Grade R	12.3 (79)	11.8 (80)	12.2 (44)	13.1 (30)
Grade P	12.2 (108)	11.5 (103)	11.9 (48)	13.3 (28)
Ascorbic Acid Mean				
Grade R	0.52 (83)	0.59 (77)	0.53 (44)	0.78 (29)
Grade P	0.62 (101)	0.55 (95)	0.47 (45)	0.73 (30)
Phosphatase Mean				
Grade R	4.1 (82)	11.0 (76)	10.6 (45)	8.2 (30)
Grade P	4.4 (102)	11.1 (99)	10.1 (47)	7.4 (32)

survey the grading is dependent only on the statements of the patients, and may therefore be open to considerable error.

SUMMARY.

(1) Haemoglobin, plasma ascorbic acid and plasma alkaline phosphatase have been estimated on a random series of pregnant women, attending the antenatal department of this hospital. The mean levels and distributions at different stages of pregnancy are given.

(2) Evidence of nutritional deficiencies is discussed. There is no reason to suppose that any incidence occurs of a general nutritional deficiency.

(3) The results do not show that income level affects the nutritional state.

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Haemoglobin Values in Female Workers

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THERE is ample evidence available to prove that a low haemoglobin value is not uncommon in the female when the diet is poor in iron. In peacetime such an anaemia was prevalent in areas where economic distress and financial hardship prevailed. Anaemia and poverty went hand in hand. The work of Davidson in Aberdeen was pioneer in this field. In war, although the power to purchase may be at hand, the restrictions may be such as to diminish the intake of foods rich in iron and thereby produce a state of anaemia. It is for this reason that we investigated 2,000 females at an ordnance factory in the Midlands towards the end of last year (1942). The factory was selected for its proximity to London. Half of the workers are drawn from the surrounding areas, but the ones resident in hostels are drawn from all over the country and, therefore, cannot be regarded as typical of any one area. In fact, the majority came from large industrial areas in the North and from Scotland.

We approached the problem with some interest, for we had the opportunity of examining 2 distinct groups. The one 1,000 were women living at home and were travellers to and from their homes to the factory; the other 1,000 were residents at a hostel near the factory, freed from the difficulties of travelling and of domestic responsibility. In the former group, their food was their own affair; the latter group were fed and housed, and their intake of food was known.

We were seeking information on many points. Are the women to-day showing a greater degree of anaemia than in peacetime? Are they receiving sufficient iron in their food to meet their demands? Are those who have to return to their homes less well off than those who are fed in hostels? Do those in hostels receive sufficient iron-containing foods to retain a good haemoglobin value?

There was no selection, and all the 2,000 were volunteers. Indeed, it can be said that all who were approached (while at work) volunteered with readiness, and it is meet and proper that this willingness to co-operate is recorded and acknowledged.

HAEMOGLOBIN DETERMINATION.

While the estimation of haemoglobin is a relatively simple procedure and one which has been performed in every hospital and laboratory for half a century, there is still a good deal of disagreement in medical circles regarding the methods employed and the interpretation of results. This unsatisfactory position has been recognized by the Medical Research Council in a recent attempt to procure uniformity by the advocacy of the Haldane method, with tube and pipette standardized by the National Physical Laboratory. The Haldane method

necessitates coal gas, and, unfortunately, our work was prosecuted in factory areas where coal gas could not be laid on. We therefore adopted King's method[1] of the alkaline haematin, and recorded our results in grammes. There is much to commend this way of recording haemoglobin values.

Osgood, Haskins and Trotman,[2] in 1932, concluded that the average haemoglobin value for women was 13.9 g. with a 90 per cent range of 12 to 15.5 g. It has long been accepted that the Haldane 100 per cent is equivalent to 13.8 g. Wintrobe[3] gives 14.0 g. (±2.0) as the normal figure for women and 16 g. for the male. Wintrobe also remarks on the "habit of expressing haemoglobin values in percentage as an unfortunate custom difficult to overcome". "A number of different values have been arbitrarily selected as the equivalent of 100 per cent. Thus the values as low as 13.8 g. and as high as 17.2 g. per 100 c.cm. of blood are still employed as the equivalent of 100 per cent" (Wintrobe).

Price Jones[4] assessed the haemoglobin of 100 young women in 1931 and found the average to be 13.5 g., while Jenkins and Don,[5] in 1933, recorded an average of 13.8 for 116 females.

The alkaline haematin method originated by Wu, used and recommended by Peters and van Slyke and by King in this country, was adopted by us all in our determinations. We used the photo-electric colorimeter and followed King's technique closely. This method measures the total pigment, is simple to use, and the standard for comparison is obtained from crystalline haemin with its known iron content. All samples were obtained from the lobe of the ear.

The hostel residents were within easy distance of the factory—a bus ride of five minutes. Each shift had separate quarters, so that those on the night shift were able to sleep undisturbed during the day. A large majority of the home residents had a journey of an hour or more following their work, and many had some housework or shopping to do on arrival. Their sleep during the day was also less certain to remain undisturbed.

The determinations were conducted in the rest rooms adjoining the explosive shops, where the temperature remained constant. The vast majority were single women of 18 to 25 years of age. The duration of service varied, some having served 3 years, others only 3 months. Only a proportion of these 2,000 women were constantly exposed to T.N.T. in their work and, as we did not wish to inquire specifically into the haemoglobin values in relation to toxic substances, but rather to record the values in the female at work of a varied kind, we will not attempt to compare results in relation to actual occupation. On the whole, it can be said that the work is not hard or heavy, the shops are well spaced, there is no crowding and, at least during the day, there is abundant fresh air. The factory where our investigations were conducted is situated in the heart of the country, the women appear happy at their work, and there is relative security and reasonably good wages. The hours are also good. The morning shift is 48 hours a week, the afternoon 42 hours a week and the night 54 hours a week, giving an average of 48 hours.

Results are divisible into two main groups, those resident at home and those resident in hostel.

The first chart shows the haemoglobin values in 651 single females who reside at home, 498 of whom are under 25 years of age. It is seen that 267 (41 per cent) show a haemoglobin of 14.1 g. or more, and that 460 (70 per cent) show a haemoglobin of 13.1 g. or more. Seventy-seven recorded 12 g. or less, a percentage of 11.9, while 38 showed values of 11 g. or less, a percentage of 5.8. In other words, if we are to regard

a value below 12 g. as abnormal, some 10 per cent of these single women show this state, while about 5 per cent show figures below 11 g. and are definitely anaemic.

Of these 2,000 females 788, or 39.4 per cent, show haemoglobin values of over 14 g., while 1,385, or 69.2 per cent, show values of over 13 g.; 1,771, or 88.5 per cent,

SINGLE WOMEN RESIDENT AT HOME.

Grammes of haemoglobin	Years						Total
	18–20	21–25	26–30	31–40	41–50	51 and over	
Up to 8.0		2					2
8.1– 9.0	1	7	1		1		10
9.1–10.0	4	8	2	1			15
10.1–11.0	6	2	1	2			11
11.1–12.0	12	20	7				39
12.1–13.0	37	46	13	14	4		114
13.1–14.0	55	99	23	14	2		193
14.1–15.0	63	95	26	20	3	2	209
15.1–16.0	14	22	5	9	1	1	52
16.1 and over	1	4			1		6
	193	305	78	60	12	3	651

The married women resident at home numbered 349, and it is seen from the figures that they differ from the unmarried in that the percentage showing values above 13.1 g. is appreciably less—64 per cent (226). Fifty-six, or 16 per cent, record figures of 12 g. or less; and 36, or 10.3 per cent, values of 11 g. or less.

show values above 12 g., while 229, or 11.5 per cent record figures of 12 g. or less. Below 11 g. or less are 114, or 5.7 per cent.

The hostel residents were in the vast majority unmarried: 943 single and 57 married. Of the single, more than two-thirds were under 25 years of age, and only 120 were over 30 years of age. As can be

MARRIED WOMEN RESIDENT AT HOME.

Grammes of haemoglobin	Years				Total
	Up to 30	31–40	41–50	50 and over	
Up to 8.0		2			2
8.1– 9.0	3	1	3		7
9.1–10.0	6	1	7		14
10.1–11.0	4	4	5		13
11.1–12.0	10	5	5		20
12.1–13.0	35	25	11	1	67
13.1–14.0	39	27	14	2	82
14.1–15.0	39	24	18	8	89
15.1–16.0	17	12	14	4	47
16.1 and over	2	3	2	1	8
	150	104	79	16	349

SINGLE WOMEN RESIDENT IN HOSTEL.

Grammes of haemoglobin	Years					Total
	18–20	21–25	26–30	31–40	41–50	
Up to 8.0		4	2	1		7
8.1– 9.0		3	3	3		9
9.1–10.0	2	6	1			9
10.1–11.0	4	6	1	2		13
11.1–12.0	7	27	10	9		53
12.1–13.0	37	104	30	27		198
13.1–14.0	49	157	67	27	3	303
14.1–15.0	39	148	44	25	7	263
15.1–16.0	12	41	11	11	4	79
16.1 and over	2	3	3	1		9
	152	499	172	106	14	943

MARRIED WOMEN RESIDENT IN HOSTEL.

Grammes of haemoglobin	Years				Total
	Up to 30	31–40	41–50	51 and over	
Up to 8.0					
8.1– 9.0					
9.1–10.0					
10.1–11.0	1		1		2
11.1–12.0	1	2			3
12.1–13.0	1	1	3	2	7
13.1–14.0	9	3	5	2	19
14.1–15.0	10	5	3		18
15.1–16.0	1	1	2	2	6
16.1 and over					
	23	12	15	7	57

seen from the figures of the unmarried, out of a total of 943, 351 (37 per cent) showed a haemoglobin of 14.1 or more, and 654 (69 per cent) a haemoglobin of 13.1 or more. Ninety-one, or 9.6 per cent, recorded values of 12 g. or less, and 38, or 4 per cent, below 11 g.

The married residents in hostel are a small group of 57. This group is too small for analysis, but will be added to the larger group of married resident at home.

The two groups, 1,000 each, show little difference, although there is possibly a better picture in the hostel group. In both we can state that the haemoglobin values are relatively good. The combined figures are shown in the following table:

Grammes of haemoglobin	Home	Hostel	Total
Up to 8.0	4	7	11
8.1– 9.0	17	9	26
9.1–10.0	29	9	38
10.1–11.0	24	15	39
11.1–12.0	59	56	115
12.1–13.0	181	205	386
13.1–14.0	275	322	597
14.1–15.0	298	281	579
15.1–16.0	99	85	184
16.1 and over	14	11	25
	1000	1000	2000

Of these 2,000 females 788, or 39.4 per cent, show haemoglobin values of over 14 g., while 1,385, or 69.2 per cent, show values of over 13 g.; 1,771, or 88.5 per cent, show values above 12 g.; while 229, or 11.5 per cent, record figures of 12 g. or less. Below 11 g. or less are 114, or 5.7 per cent.

When the additional work many of these women do in bringing up a family, travelling long distances to work and attending to their manifold duties, is realized it is pleasing to record such relatively low incidence of anaemia in married women at this stage of the war.

	Total Home		Total Hostel		Total	
	1000	per cent	1000	per cent	2000	per cent
Over 14 g.	411	41.0	377	37.7	788	39.4
Over 13 g.	686	68.6	699	69.9	1385	69.2
Over 12 g.	867	86.7	904	90.4	1771	88.5
12 g. or less	133	13.3	96	9.6	229	11.5
11 g. or less	74	7.4	40	4.0	114	5.7

The above table shows that the hostel figures, all in all, are superior to those of the home residents.

A similar finding is obtained when all the single women up to the age of 30 are listed into 2 groups of home and hostel, making a grand total of 1,399.

	Single home		Single hostel		Total single	
Number	576	per cent	823	per cent	1399	per cent
Over 14 g.	230	40.0	303	36.8	533	38.0
Over 13 g.	407	70.0	576	70.0	983	70.0
Over 12 g.	503	87.0	747	91.0	1250	89.0
12 g. or less	73	13.0	76	9.0	149	11.0
11 g. or less	34	6.0	32	3.6	66	4.7

Here again the hostel figures are somewhat superior to the home resident figures.

The married women numbered 406, most of whom lived at home, undoubtedly contributing their share in domestic duties. The figures of their haemoglobin values are, as we should expect, somewhat less good than those of the single women but, even so, only 8 per cent of these show haemoglobin values which are decidedly low.

	406	per cent
Over 14 g.	170	42.0
Over 13 g.	271	66.0
Over 12 g.	345	85.0
12 g. or less	61	15.0
11 g. or less	38	8.0

Analysis of those Showing Haemoglobin Values Below 11 g.

Values below 11 g. are to be regarded as definitely abnormal. It is true that many women appear to carry on quite free of symptoms yet showing this degree of anaemia, and it often surprises the clinician how relatively well many seem to fare and how free they are of symptoms of ill-health. On the other hand, we all well know the immediate benefit that is realized when such a state of anaemia is corrected.

Of our series of 2,000 women, 114 showed haemoglobin values of 11 g. or below. We can reasonably assume that the administration of iron would raise these values and in all probability increase their sense of well-being. It is to be admitted that these 114 people are working in a factory where toxic risks are run and where there is a full-time and adequate medical service: 114 in 2,000 means over 1,000 in 20,000 and, in itself, is sufficient reason for greater attention to be

paid to the determination of haemoglobin in people who are to undergo toxic hazards if we are to do our medical utmost to see that only fit persons are so exposed. The 114 were distributed as follows:

	Home	Hostel	Total
Single	38	38	76
Married	36	2	38
	74	40	114

Although the number is fortunately small, it is seen that there is a higher proportion of married women showing this grade of anaemia. Among the married a total of 406 (9.3 per cent) show this grade of anaemia; while of the total single, 1,594, the percentage is 4.7. It is also seen that there are more among those resident at home than among those at the hostel.

The Single Resident at Home.

This group includes 38 women. Menorrhagia was present in 3. Past recent infection had occurred in 6. In the remainder there was no factor in the history, past or present, we could connect with the existing anaemia. The majority had been in the factory service for a good time, 31 having served for a year or more.

3 months	6 months	9 months	1 year
4	2	1	6
1½ years	2 years	2½ years	3 years
7	7	5	6

Fourteen had been away sick for various reasons, but the remainder, 24 in number, in spite of their low haemoglobin values, remained at their work. As many as 23 spent two or more hours of their day travelling to and from their work. Although meals are provided in the factory canteen, only a minority of the workers partake of a hot dinner of meat and vegetables. It is interesting to note that among these 38 anaemic women only 4 partook of these meals occasionally and none regularly.

The Married Woman Resident at Home.

This group includes 36 women.

		Total number of children
Up to 30 years of age	13	4
31 to 40 years of age	8	20
41 and over	15	57
	36	

The number of children increases in the 3 groups. The 15 women over 40 years of age were mothers of 57 children—a substantial number—and with children the domestic responsibilities must also increase. In the first group, 4 enjoyed freedom from or only light responsibilities, while in the other 2 groups all confessed to heavy domestic duties. One of these latter women did remark that she was, however, relieved of her weekly washing!

Menorrhagia was a symptom complained of by 5, and 2 admitted to a postpartum haemorrhage from which date their anaemia persisted. History of recent infection was found in 8. Twenty gave no history of previous ill-health and, in spite of their anaemia, had had no leave of absence. Thirty-two had served a year or more, and 13 had served 2 to 3 years. Travelling appears to be a factor of some significance, for 25 spent 2 hours or more out of their day (or night) travelling to and from the factory. Only 1 admitted to partaking of the canteen meal regularly and 11 occasionally.

Behind these figures there is a fortitude which is worthy of respect and admiration. These are 2 examples:

A woman of 34 and the mother of 5 children, with heavy domestic duties, has worked in the factory for 2½ years. 1½ hours of her day are occupied in travelling. In spite of showing a haemoglobin of only 7 g. she has taken no sick leave for the 2½ years, although she admits to taking 1 in 14 days to attend to her household duties.

Another, a woman of 41 and the mother of 6 children, suffering from menorrhagia since her last childbirth, and with heavy duties at home and a record of 2 years' service, 2 hours of her day occupied in travelling, shows a haemoglobin of 9 g. yet she has taken no sick leave.

The Single Women Resident in Hostel.

With good food and healthy surroundings, the incidence of anaemia should be less in a series of young women living in a hostel than in a similar series living at home with its attendant present-day difficulties. But, even in the hostel series of 1,000, there are 40 women who show a haemoglobin of 11 g. or less and who must, therefore, be regarded as anaemic. Of these 40, 38 are single.

One only complained of menorrhagia and 7 gave a history of recent infection. The others did not give any history which could in any way account for their low haemoglobin. Twenty-three had remained at their work without sick leave. Their period of service may explain, in part, the occurrence of anaemia in this hostel group, for out of the 38 only 10 had lived in the hostel for more than 6 months, while 28 were relatively newcomers. If we are to assume that the food of the hostel can be a potent influence in maintaining a good haemoglobin, we must admit that the shortness of the period during which these young women have lived in the hostel may be an explanation for their low values. It is certainly true that the similar series of 38 resident at home showed an opposite state, for 31 out of the 38 had served for a year or more in the factory. It will be well worth while repeating these blood examinations in a year's time.

From a study of these 14 anaemic women it is seen that the group of married women living at home shows the highest incidence —36 out of a total of 349—a percentage of 10.3. Indeed, it is not surprising when we learn how full their day must be, with the travelling, the household duties, the children (57 among 15 mothers in 1 group), all in addition to their work in the factory. It is surprising how many remain at their task in spite of these extra duties and anaemia. Their high sense of duty in the face of this handicap is not unworthy of recognition.

Menorrhagia was complained of by 9, a symptom which might be in varying measure responsible for the anaemia. Recent infection might also be related to the anaemia, and there are records of 21 out of the 114 having suffered such an infection. In the remainder, there was no factor which could readily explain the anaemia.

Inquiry disclosed that this group of women use the factory canteen as little as the rest of the workers for, out of the 74 resident at home, only 15 admitted to the occasional use of the canteen and only 1 regularly. This is a pity, for their need is good food.

The difference in the incidence of anaemia between those resident at home and those in hostel is not striking. Of the 851 single women at home, 38, or 5.8 per cent, showed an anaemia, while out of the 943 resident in hostel, 38, or 4 per cent, showed this degree of anaemia. This lack of striking difference may be accounted for by our observation that only 10 of the hostel group of 38 had resided there for 6 months. In other words, the hostel figures a year hence may show a better state than we record to-day.

While the incidence of anaemia is not high, this figure of 5.7 per cent in a total of 2,000 is found within a factory where exposure to toxic risks is a daily event. There is no evidence that a better or worse state of affairs exists in the other factories, but a greater and wider interest seems called for in the simple determination of haemoglobin as a routine measure in persons who appear pale. It can hardly be wise to allow women with haemoglobin values as low as 10 g. to continue work on T.N.T. and other poisons. It also appears that more elastic measures are needed in dealing with married women; those who are over 40 years of age and who have large families (and who are more readily rendered anaemic) should be dealt with on a different standing from those who are younger and whose responsibilities are so much less.

Mention has already been made of the confusion which exists in interpreting values obtained by various methods of haemoglobin determination. The Haldane, which has been the most popular and widely-used method in this country, needs correction from time to time, and no great confidence can be placed in past results obtained by such a method that is not checked by some of the other methods, such as the oxygen capacity or the iron content. With the help of Professor Earl J. King and his colleague, Mrs. Gilchrist, we compared the new Haldane (passed by the National Physical Laboratory) with the alkaline haematin method used by us. Several independent determinations were made on the same blood by a direct and an indirect method in addition to the determination of iron in the samples.

From the experiments, it is concluded that 100 per cent Haldane is equivalent to 14.8 g. of haemoglobin and not 13.8 g. as formerly believed. If this is established and accepted it makes comparison with previous results still more difficult. If, however, we take the 100 per cent Haldane of to-day as equivalent to 14.8 g. then:

14 g.	= 94 per cent
13 g.	= 88 ,, ,,
12 g.	= 81 ,, ,,
11 g.	= 74 ,, ,,
10 g.	= 67 ,, ,,

Interpreting our results on this basis, and converting them into the new Haldane, our figures for these 2,000 women could be recorded as follows:

39.4 per cent,	haemoglobin of 94 per cent or over
69.2 ,, ,,	,, 90 ,, ,,
88.5 ,, ,,	,, 82 ,, ,,
11.5 ,, ,,	,, under 82 per cent
5.7 ,, ,,	,, ,, 75 ,,

It is doubtful whether we can compare our results with past values. Wills[6] published a study of 544 women in 1942, and in this series the mean haemoglobin was recorded as 12.3 g. and in a sub-group of nurses and students living in the country (where the diet was reported as poor) a mean of 11.6 g. These figures are certainly low, but it appears they found that factory workers (a number of 159) showed a better state, as the mean haemoglobin was 13 g. Davidson[7] reported that 25 per cent of a series of childless women showed haemoglobin values below 85 per cent, and that of women with children 48 per cent showed values less than 85 per cent haemoglobin; but in his more recent study Davidson[8] finds that only 7 per cent of adult females show a haemoglobin below 80 per cent, and he remarks "if haemoglobin values of this magnitude are found after nearly 4 years of war . . . then there is reason to believe that average haemoglobin levels even higher than those proposed by Price Jones might obtain in days of peace." From this we conclude that Davidson's findings in war are superior to those found in peace in "distressed" areas.

Although it is not possible to make any accurate comparison with records obtained before the war, it can be stated that the findings here recorded are moderately satisfactory and, in spite of wartime restrictions, the incidence of anaemia appears no greater than in times of peace.

In keeping with all other series the married women (especially those with large families) show a higher incidence of anaemia.

The young women in hostels, on the whole, show the best figures, and this is significant when it is recalled that they were in the main drawn from large industrial areas where the economic conditions were not good, and many were included who had resided only a short space of time in the hostels.

The haemoglobin determinations on 2,000 women showed results which appear to be relatively good. Only some 5 per cent showed haemoglobin below 11 g., whilst almost 70 per cent are above 13 g. The young women fed and housed in hostels showed the best haemoglobin values.

The married women showed a less satisfactory state and anaemia was almost twice as frequent in this group.

Haemoglobin values of 11 g. or less were encountered in 114 out of 2,000 (5.7 per cent). That this occurs in workers who are daily exposed to toxic risks in factories where there is a full and adequate medical service emphasizes the need for more attention to the haemoglobin determination of the blood. This simple examination should become a routine on all persons who appear pale.

ACKNOWLEDGMENT.

We owe sincere gratitude to many who have helped in this undertaking. Air Vice Marshal Sir David Munro, K.C.B. (as Chief Medical Officer of the Ministry of Supply when the work was executed), Professor E. C. Dodds, F.R.S., and Professor Sir J. Drummond gave constant encouragement. Professor E. J. King readily placed all his resources at our disposal. To Dr. Attwater (the senior Medical Officer at the factory where the main investigations were carried out), and to all the medical officers, we wish to record our thanks. The Birmingham University kindly housed one of us while conducting some of the analyses, and we also wish to acknowledge the help of Professor R. H. Hopkins and Dr. Robert Gaddie.

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Calcium and Phosphorus Metabolism in Pregnancy

(A Survey Under War and Post-war Conditions)

Preliminary Communication

BY

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DURING many years a routine survey of metabolism, including mineral metabolism, of a large number of patients during pregnancy seemed to show that a positive balance of calcium throughout pregnancy influenced not only the well-being of the patient but the character of the labour and the postnatal welfare of mother and child. Experience, however, demonstrated the extreme difficulty of ensuring a positive calcium balance in a considerable minority of women. This is due to the complexity of factors governing the absorption and retention of minerals, in particular, calcium. In the literature[1, 2, 3, 4] at least the following factors are mentioned:

(1) Gastric acidity.
(2) The potential acid-base value of the food.
(3) The acid-base balance of the body as a whole.
(4) The acidity of the urine.
(5) The calcium : phosphorus ratio in the diet.
(6) Ingestion and digestion of fat.
(7) The motility of the intestinal tract.
(8) Parathyroid function.
(9) Thyroid function.
(10) Ovarian, pituitary, and possibly other endocrine influences.
(11) Vitamin D ingestion and synthesis.

It is also realised that general constitutional factors and reactions to favourable and unfavourable emotional stimuli exert an influence, which, as yet, is not susceptible of quantitative measurement.

SCOPE OF SURVEY.

To elucidate some of these factors, a comprehensive and long-term survey was planned in 1942, to include as many clinical and biochemical data as possible. The objects of such a survey were to find out:

1. How far working-class diets during pregnancy can be considered adequate in the main nutritional requirements apart from minerals.

2. Whether actual deficiencies, correlated to functional disturbances, arise during pregnancy on the average diet consumed by working-class mothers.

3. Whether supplementary feeding of calcium phosphate alone would correct any errors detected.

4. Whether Calciferol, in addition to calcium phosphate, showed better results.

5. The effects of Calciferol supplements without the addition of the calcium salt.

6. The effects of varying doses of Calciferol with or without the calcium supplement—to arrive at an " optimum " dosage.

Thanks to the facilities provided by Mr. O'Sullivan, Obstetric Surgeon to Out-Patients at the City of London Lying-in Hospital, the survey was started in April 1943. The biochemical part of the work will be completed in the summer of 1946, and the final postnatal details collected by the summer of 1947.

The survey, which will be described in detail elsewhere, covers full clinical data, antenatal, natal and postnatal, of 50 subjects selected for their co-operativeness and

intelligence at the Out-Patients' department. The biochemical survey comprises a 48-hour period of weighing and measuring food and drink, the collection of all urine and stools over the same period, and a complete fasting blood analysis on each occasion—the intake figures being calculated from McCance and Widdowson's Tables,[5] the blood and excreta being analysed in the writer's laboratory.

The majority of the women are healthy primiparae, a few cases have been included whose general health seemed good but who had previously miscarried or had a stillbirth. A small number are also being included who had previously given birth to 1 healthy child.

Scope of Present Communication.

The 50 subjects have been divided into groups. The present communication deals with 2 groups:

(1) A control group, whose calcium figures are given in Section 1 of Table I, and who were encouraged not to alter their usually dietary habits. They were also encouraged to avail themselves of the daily pint of milk under the National Milk Scheme. They also "benefited" from the chalk added to bread throughout the survey—7 ounces to 280 pounds of flour.

(2) A group of subjects, whose calcium figures are given in Section 2 of Table I, otherwise similar to the control group, but who were given a supplement of calcium phosphate in doses which worked out to the following amounts of calcium and phosphorus elements per 24 hours:

	Calcium	Phosphorus
3rd to 5th months ...	0.64 g.	0.282 g.
6th to 7th months ...	0.95 g.	0.423 g.
8th month to term ...	1.26 g.	0.564 g.

Table I. The calcium figures given in this table have been extracted from a comprehensive tabulation of all the biochemical figures arrived at during each 48-hour investigation, that is:

(*a*) Blood—glucose, uric acid, inorganic phosphorus, cholesterol, calcium, urea, Amino-N, protein, refraction, viscosity, erythrocyte sedimentation-rate and haematology;

(*b*) Intake—protein, fat carbohydrate and calories, as well as acid or base predominance of the diet, expressed in milli-equivalents;

(*c*) Similar detailed phosphorus intake and output figures to the calcium figures in Table I;

(*d*) *p*H and titrateable urinary acidity of each specimen passed during the 48-hour period as well as creatinin, chlorine and indican in the urine;

(*e*) Faecal *p*H, et cetera.

Discussion of Section 1, Table I.

Cases Nos. 1–6 were studied throughout pregnancy; Nos. 1 (age 24), 2 (age 31), 4 (age 31), 5 (age 24), 6 (age 21), were primiparae, No. 3 (age 25), had a normal previous pregnancy. No. 1 took a small daily dose of cod liver oil. None of the others took any vitamin supplement which might influence calcium or phosphorus metabolism.

Cases Nos. 7–12 were subjects who could only be investigated during the early part of pregnancy—either because of a spontaneous miscarriage, as in Cases Nos. 7 (age 23) and 8 (age 29), or a rise in blood-pressure followed by acute pyelitis, as in Case No. 10 (age 29), or because they left London owing to bombing, as in Cases Nos. 9 (age 29), 11 (age 32), and 12 (age 28).

With regard to Cases Nos. 13–22, the figures which are given at the end of Section 1 represent the findings of their initial investigations before supplementary feeding with calcium phosphate was started.

TABLE I.

TABULATION OF CALCIUM INTAKE AND OUTPUT FIGURES.

(The figures represent the findings of a 48-hour balance period in terms of grammes of calcium element.)

Section 1.

Date	Week of pregnancy	Case No.	Calcium intake				Calcium in blood	Calcium in urine	Calcium in faeces	Total calcium out	Calcium balance
			Milk	Cheese	Other foods	Total					
28. 2.1943	13	1	1.51	Nil	0.30	1.81	9.5	0.69	3.04	3.73	−1.92
10. 4.1943	19		1.32	Nil	0.28	1.60	10.4	0.54	2.60	3.14	−1.54
27. 5.1943	25		1.80	0.24	0.23	2.27	9.8	0.63	1.59	2.22	−0.05
12. 7.1943	31		1.15	Nil	0.30	1.45	9.3	0.73	3.84	4.57	−3.12
15. 3.1943	12	2	0.68	0.39	0.26	1.33	10.7	0.40	2.20	2.60	−1.28
28. 4.1943	19		2.10	0.37	0.27	2.74	10.5	0.84	3.64	4.48	−1.74
9. 6.1943	26		1.82	0.24	0.36	2.42	9.9	0.48	3.75	4.23	−1.81
20. 7.1943	32		1.42	0.74	0.35	2.51	9.9	0.39	3.10	3.49	−0.98
31. 8.1943	37		1.20	0.58	0.43	2.21	10.4	0.24	1.77	2.01	+0.20
28. 6.1943	7	3	0.74	Nil	0.45	1.19	10.7	0.67	1.58	2.25	−1.06
3. 8.1943	13		0.91	0.44	0.46	1.81	10.3	0.37	1.58	1.95	−0.14
15. 9.1943	19		0.84	0.67	0.55	2.06	10.8	0.51	1.87	2.38	−0.32
1.11.1943	25		0.98	0.89	0.71	2.58	9.5	0.69	2.88	3.57	−0.99
13.12.1943	31		1.22	0.45	0.61	2.28	10.2	0.77	3.03	3.80	−1.52
30. 1.1944	37		1.88	0.82	0.34	3.04	10.0	1.00	6.00	7.00	−3.96
20.10.1943	12	4	1.13	0.54	0.27	1.94	11.6	0.91	1.90	2,81	−0.87
24.11.1943	17		1.42	0.23	0.46	2.11	10.2	0.58	2.45	3.03	−0.92
4. 1.1944	23		2.05	Nil	0.38	2.43	9.9	0.37	5.05	5.50	−3.07
15. 2.1944	29		1.54	0.51	0.57	2.62	10.2	0.59	3.24	3.83	−1.21
13. 4.1944	36		1.44	Nil	0.29	1.73	10.0	0.36	2.18	2.54	−0.81
6. 3.1944	21	5	0.72	0.45	0.41	1.58	10.0	0.76	0.84	1.60	−0.02
27. 4.1944	27		0.47	Nil	0.69	1.16	10.0	0.81	0.99	1.80	−0.64
7. 6.1944	33		1.26	Nil	0.61	1.87	10.4	0.72	0.78	1.50	+0.37
10. 7.1944	38		0.54	0.22	0.45	1.21	9.7	0.32	2.44	2.76	−1.55
16. 5.1944	14	6	1.34	0.24	0.47	2.05	10.0	0.44	1.90	2.34	−0.29
30. 7.1944	21		1.52	Nil	0.50	2.02	9.2	0.48	2.10	2.58	−0.56
21. 9.1944	28		1.53	Nil	0.39	1.92	10.0	0.82	0.99	1.81	+0.11
25.10.1943	9	7	1.97	0.16	0.39	2.52	10.7	0.61	2.42	3.03	−0.51
24. 4.1944	9	8	0.72	Nil	0.42	1.14	10.6	0.64	1.43	2.07	−0.93
19. 5.1944	12	9	0.94	0.57	0.36	1.87	10.5	0.74	1.74	2.48	−0.61

TABLE I.

Section 1 (*continued*)

Date	Week of pregnancy	Case No.	Calcium intake				Calcium in blood	Calcium in urine	Calcium in faeces	Total calcium out	Calcium balance
			Milk	Cheese	Other foods	Total					
4. 5.1943	20	10	1.60	Nil	0.41	2.01	10.7	1.22	0.94	2.16	−0.15
4.10.1944	9	11	0.58	Nil	0.74	1.32	10.9	0.77	0.69	1.46	−0.14
30. 9.1944	10	12	0.97	0.23	0.41	1.61	9.9	0.73	3.05	3.78	−2.17
18.11.1944	17		0.94	0.41	0.71	2.06	10.4	0.39	4.50	4.89	−2.83
3. 3.1943	9	13	0.86	0.52	0.42	1.80	10.5	0.34	2.45	2.79	−0.99
9. 4.1943	14		1.20	0.49	0.43	2.12	10.2	0.49	3.05	3.54	−1.42
15. 3.1943	11	14	1.08	Nil	0.31	1.39	10.8	0.39	1.24	1.63	−0.24
28. 5.1943	17		1.90	Nil	1.10	3.00	10.6	0.83	2.55	3.38	−0.38
20.10.1943	12	15	1.01	0.23	0.27	1.51	11.0	0.53	1.80	2.33	−0.82
3. 2.1944	15	16	0.96	0.45	0.40	1.81	11.4	0.99	2.71	3.70	−1.89
23. 9.1944	11	17	1.52	Nil	0.38	1.90	11.5	0.74	1.90	2.64	−0.74
9.12.1944	15	18	1.28	0.12	0.59	1.99	10.8	0.53	2.50	3.03	−1.04
8. 3.1943	16	19	1.56	0.12	0.19	1.87	10.3	0.37	2.80	3.17	−1.30
9. 4.1943	20		1.16	0.36	0.19	1.71	9.8	0.49	1.62	2.11	−0.40
15. 4.1943	10	20	1.63	0.61	0.44	2.68	10.3	0.71	2.12	2.83	−0.15
31. 5.1943	16		1.50	Nil	0.38	1.88	10.7	0.79	1.05	1.84	+0.04
17.10.1943	12	21	1.70	0.22	0.28	2.20	11.4	0.94	3.24	4.18	−1.98
22. 1.1944	21	22	0.96	Nil	0.25	1.21	10.2	0.63	1.14	1.77	−0.56

NOTE—The figures on each line represent the findings of a 48-hour balance period—figures in the text for a 24-hour period are arrived at by halving.

TABLE I.

Section 2

Date	Week of pregnancy	Case No.	Calcium intake					Calcium in blood	Calcium in urine	Calcium in faeces	Total calcium output	Calcium balance
			Milk	Cheese	Other foods	Sup.	Total					
18. 5.1943	20	13	2.02	Nil	0.50	1.26	3.78	10.3	0.78	5.40	6.18	−2.40
25. 6.1943	26		2.15	0.12	0.42	1.89	4.58	10.0	0.66	6.35	7.01	−2.43
22. 8.1943	35		1.80	0.61	0.26	2.52	5.19	9.8	0.43	4.32	4.75	+0.44
8. 6.1943	23	14	1.17	Nil	0.47	1.89	3.53	10.0	0.75	3.25	4.00	−0.47
20. 7.1943	29		1.46	Nil	0.55	2.52	4.53	10.4	0.91	3.18	4.09	+0.44
31. 8.1943	35		1.55	Nil	0.44	2.52	4.51	10.5	0.65	1.70	2.35	+2.18
23.11.1943	17	15	1.66	Nil	0.53	1.26	3.45	11.0	0.73	2.12	2.85	+0.60
9. 1.1944	23		1.45	0.37	0.50	1.89	4.21	10.2	0.42	7.65	8.07	−3.86
18. 2.1944	29		1.91	0.29	0.59	Nil	2.79	9.9	0.66	3.96	4.62	−1.83
6. 4.1944	36		1.81	Nil	0.96	2.52	5.29	10.7	0.26	1.58	1.84	+3.45
21. 3.1944	21	16	0.86	0.23	0.42	1.26	3.77	10.5	0.68	1.90	2.58	+1.19
10. 5.1944	28		1.50	0.11	0.36	1.26	3.23	9.7	0.96	6.50	7.46	−4.23
30. 6.1944	35		0.81	0.19	0.43	1.89	3.32	10.1	0.91	4.55	5.46	−2.14
4.11.1944	17	17	2.01	Nil	0.31	1.26	3.58	10.4	0.68	1.06	1.74	+1.84
14.12.1944	23		2.28	0.41	0.33	1.26	4.27	10.7	0.73	0.82	1.55	+2.72
26. 1.1945	29		1.75	Nil	0.37	1.89	4.01	9.7	1.03	0.61	1.64	+2.37
9. 3.1945	35		1.26	0.27	0.44	Nil	1.97	10.9	0.61	1.82	2.43	−0.46
27. 1.1945	21	18	2.21	0.41	0.51	1.45	4.58	10.4	0.68	3.55	4.23	+0.35
12. 3.1945	27		2.21	Nil	0.51	2.08	4.80	10.8	0.88	5.80	6.68	−1.88
23. 4.1945	33		2.41	0.27	0.61	2.08	5.37	9.8	0.96	5.90	6.86	−1.49
28. 5.1945	38		2.52	Nil	1.12	2.71	6.35	10.5	0.38	5.10	5.48	+0.87
19. 5.1943	26	19	1.32	0.06	0.55	1.89	3.82	—	0.50	5.39	5.89	−2.07
25. 6.1943	31		1.12	0.12	0.32	2.52	4.08	9.1	0.57	4.64	5.21	−1.13
3. 8.1943	37		1.32	0.11	0.22	2.52	4.17	8.9	0.32	2.12	2.44	+1.73
12. 7.1943	21	20	1.00	0.12	0.51	1.89	3.52	10.1	0.76	4.52	5.28	−1.76
18. 8.1943	28		2.30	0.48	0.33	1.89	5.00	9.7	1.09	2.96	4.05	+0.95
4.10.1943	36		1.58	0.22	0.35	2.52	4.67	9.9	0.63	3.90	4.53	+0.12
22.11.1943	17	21	1.80	0.23	0.32	1.26	3.61	11.0	0.94	3.34	4.28	−0.67
5. 1.1944	23		1.46	0.11	0.40	1.89	3.86	10.6	0.86	3.39	4.25	−0.39
16. 2.1944	29		1.58	0.23	0.49	1.89	4.19	10.0	0.94	4.50	5.44	−1.25
23. 3.1944	34		1.88	Nil	0.40	2.52	4.80	9.3	1.13	2.56	3.69	+1.11
26. 2.1944	27	22	1.94	Nil	0.43	1.26	3.63	10.2	1.20	1.16	2.36	+1.27
10. 4.1944	33		1.83	Nil	0.62	1.89	4.34	9.7	0.62	1.66	2.28	+2.06

Discussion of Section 2, Table I.

The figures given cover the investigations carried out in Cases Nos. 13–22 from about the 4th month of pregnancy to term on supplements of calcium phosphate in the doses specified above.

Cases Nos. 14 (age 31), 15 (age 23), 16 (age 26), 18 (age 26), 19 (age 24), 20 (age 34), and 22 (age 21) were primiparae. No. 13 (age 31) had been induced at the 32nd week of a previous pregnancy, in August 1941; because of pregnancy toxaemia, resulting in a small stillborn male foetus. No. 17 (age 30) and No. 21 (age 22) had both had 1 previous normal pregnancy, the former in 1935, and the latter in 1941.

Owing to a miscalculation in her supplies, Case No. 15 ran out of her supplement of calcium phosphate a short time before the investigation carried out in the 25th week of her pregnancy. The supplement, was, however, resumed immediately after the investigation and was continued to term. It will be noted that there was a heavily negative calcium balance on this occasion.

Case No. 17 had considerable digestive disturbance towards the end of pregnancy and claimed that she could not take the supplement during her last investigation, carried out at the 35th week. In this case also there were negative balances of both calcium and phosphorus, even at this late stage of pregnancy.

Discussion of Calcium and Phosphorus Requirements.

A large number of correlations have been worked out on the total number, 81, of 48-hour balance periods recorded in Table I. The number of negative and positive balances are shown in Tables II and III.

Table II.

Analysis of Calcium Balances in both Control and Calcium Phosphate Groups.

Calcium.

48 Control balances (from Table I, Section 1).		33 Balances from cases supplemented with calcium phosphate (from Table I, Section 2).	
	Percentage of total		Percentage of total
41 Negative balances	86	16 Negative balances	48
4 Equilibria	8	— Equilibria	—
3 Positive balances	6	17 Positive balances	52

Table III.

Analysis of Phosphorus Balances in Both Control and Calcium Phosphate Groups.

Phosphorus.

48 Balances (as Table II).		33 Balances (as Table II).	
	Percentage of total		Percentage of total
23 Negative balances	48	13 Negative balances	39
2 Equilibria	4	3 Equilibria	9
23 Positive balances	48	17 Positive balances	52

No correlation was found between negative or positive calcium balances and:

Quantitative variations in protein intake;

Quantitative variations in fat intake;

Potential acid or base predominance of the food;

The calcium: phosphorus ratio of the ingesta;

Urinary acidity.

On the other hand, striking results were arrived at when the 81 balances in Table I were analysed in relation to calcium-intake levels. The figures, which speak for themselves, are given in Table IV.

As would be expected, no correlation could be found between the serum-calcium levels and negative or positive calcium balances. The average serum-calcium level correlating with the 56 negative balances was 10.3 mg. per cent and 10.4 mg. per cent for the 20 positive balances. Other observers[7, 8] have also shown that no reliance can be placed on the small variations in the serum-calcium level for the purpose of determining whether calcium metabolism is normal or not in any given case.

The urinary calcium figures were similarly analysed in relation to positive and negative balances. This was done because the 24-hour urinary calcium figure in male adults and non-pregnant females can often be interpreted as an expression of overflow. It was hoped, therefore, that there might also be some correlation in this series, so that a relatively simple and quick procedure such as a 24-hour urinary calcium analysis could be used as a short cut. As the average 24-hour calcium output for 57 negative calcium balances was 0.33 g. and 0.35 g. for 24 positive balances, it is clear that such a short-cut procedure cannot be relied on.

Robertson[6] gives the calcium requirements of the body during pregnancy and lactation as about 2 g. per day, and stresses the curious fact—borne out by the present survey—that there is no mechanism for conserving calcium in spite of abnormal demands made on the body. The National Research Council, U.S.A. 1941 (Food and Nutrition Board), recommends an intake of 1.5 g. of calcium during the latter half of pregnancy and 2 g. during lactation. The figures given in Table I, Section 1, show that such high intake levels are rarely arrived at in ordinary out-patient practice, and those in Table I, Section 2, that intake levels even higher than those recommended by these authorities sometimes fail to ensure a positive balance.

Macy and her co-workers[9] refer to the anxiety factor. It is noteworthy that all the observations recorded in Table I fall into the war period. It may well be that in the presence of powerful and prolonged anxiety, the "safety" levels of calcium intake, as indicated by the figures in Table

TABLE IV.

Correlation between Calcium-Intake Levels and Calcium Balances.

Intake per 24 hours	No. of balances	Balance positive	Equilibrium	Balance negative	Percentage of negative balances
Below 1 g.	27	?1*	1	25	93
Between 1.1–1.5 g.	20	2	1	17	86
,, 1.6–2.0 g.	12	4	–	8	67
,, 2.1–2.5 g.	15	10	–	5	33
,, 2.6–3.0 g.	3	2	–	1	33
Over 3 g.	1	1	–	–	0

* Balance not reliable—bowels were disturbed for several days before investigations.

IV, may be somewhat higher than under more normal conditions. More light may be thrown on this point when the figures for the post-war part of the survey have been completed and analysed.

Table V shows a less positive correlation between different levels of phosphorus intake and phosphorus balances.

TABLE V.

Correlation Between Phosphorus Intake Levels and Phosphorus Balances.

Intake per 24 hours	No. of balances	Balance positive	Equilibrium	Balance negative	Percentage of negative balances
Below 2 g.	2	1	1	–	0
Between 2.1–2.5 g.	13	1	1	11	84
,, 2.6–3.0 g.	11	4	4	3	36
,, 3.1–3.5 g.	15	11	–	4	27
,, 3.6–4.0 g.	17	7	2	8	46
,, 4.1–4.5 g.	12	7	2	3	40
,, 4.6–5.0 g.	5	3	–	2	40
Over 5 g.	4	3	1	–	0

The factors which govern phosphorus metabolism are even more numerous and complex than those which govern calcium metabolism. The phosphorus-balance figures on subjects fed on Calciferol may throw further light on this subject. These will be published at a later date.

SUMMARY.

1. The many factors known to influence calcium and phosphorus metabolism are enumerated.

2. A description is given of the general plan, scope and objective of a comprehensive survey of metabolism throughout pregnancy on 50 women. This survey covers the period of years during the war and will be completed 2 years after V.E. day and will include postnatal data.

3. The calcium intake and output figures are given in table form. These figures cover a group of control cases who were not given a supplement of calcium phosphate and a group of cases given heavy supplements of calcium phosphate. Cases who have been or are being given varying doses of Calciferol either alone or with a calcium phosphate supplement will be dealt with in later publications.

4. The figures are discussed and analysed. No particular correlation between any of the other findings and negative or positive calcium or phosphorus balances can be established.

5. The only definite correlation found and stressed is between the levels of calcium intake and negative and positive calcium balances (Table IV). The figures which emerge from this table suggest that standards quoted by various authorities to represent optimum or "safety" levels of calcium intake during pregnancy, are too low.

6. The correlation between levels of phosphorus intake and phosphorus balance is found to be more difficult of interpretation.

7. Among 12 control cases with a large predominance of negative calcium balances 1 case had a stillbirth and there were 2 spontaneous miscarriages. The 10 cases fed on calcium phosphate supplements had uneventful pregnancies and normal labours. As all the cases reported on in this

preliminary communication were investigated during wartime, the factor of anxiety is mentioned. No conclusions can, however, be drawn until the figures for the post-war section of the survey have been completed and analysed.

Conclusions.

1. Deductions cannot as yet be drawn from the findings in this survey as to optimum phosphorus intake during pregnancy.

2. The average calcium intake of pregnant women not receiving supplements of a calcium salt, is inadequate to ensure a positive balance. The usual "safety" intake levels given are probably too low. The figures given in this preliminary communication would tend to show that an intake of not less than 2 g. of calcium element from the beginning of pregnancy to the end of the 7th month and 2.5 g. from the 8th month to term should be considered as the minimum "safety" levels.

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Residential Rest during the Antenatal Period

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DURING the war emergency antenatal hostels and maternity homes were started as a result of the transfer of expectant mothers from the more heavily bombed areas to the country. The homes were often large, converted houses with little of the hospital atmosphere about them, and the impression was gained that the mothers delivered in these homes had a shorter labour than those delivered in maternity units incorporated with hospitals. The mothers confined in the maternity home usually spent some time in the antenatal hostel before delivery, where they were looked after, followed a regular routine, and had no household cares. It was thought that this period of rest and relative freedom from worry might be a factor contributing towards shorter confinements. The following investigation was therefore planned to discover evidence in favour of or against this view.

MATERIAL AND METHODS.

The case histories and clinical findings in 571 maternity patients delivered between June 1944 and June 1945 were examined. These patients fell naturally into 2 groups according to their place of delivery, either in hospital or maternity home: The groups were alike in age distribution and economic status as judged by the Registrar-General's classification. With the rationing system in force, very few of the women had failed to take up the extra allowances and vitamins given during pregnancy, so that the 2 groups had had a comparable diet throughout the antenatal period.

Dieckmann and others,[1] in dietary studies made during pregnancy, have shown that the addition of vitamins and minerals to the diet does not alter the length of labour as compared with a control group receiving no extras. Burke and Harding[2] have shown that the addition of protein to the diet, although it affects the birth weight and length of the infant, has no significant effect on the duration of labour. This has been confirmed by a committee appointed by the People's League of Health,[3] which studied the diet of 5,000 expectant mothers with regard to its effect on maternal and infant mortality and morbidity. Schuitema,[4] however, has shown that a salt-poor diet does affect the length of labour. He found that in 46 normal primiparae, on a diet containing less than 3 g. of salt in 24 hours, the average length of labour was 7.3 hours, as compared with a control group of 41 in which the average was 9.0 hours with much greater individual variation.

It is probably safe to assume that few, if any, of the hospital patients in the present series were on a salt-poor diet, owing to its unpalatability, while the group delivered in the maternity home was not on any dietary restriction while at the antenatal hostel.

In the present series of cases abnormalities attributable to pregnancy or otherwise occurred in 128 patients, either

during the antenatal period, during delivery and necessitating obstetrical interference, or during the postnatal period. In view of the variety of abnormality in these cases, and the fact that they preponderated at the hospital, they were all excluded from the series. The subsequent analysis deals only with the 443 completed normal and spontaneously delivered cases which were grouped as shown in Table I.

TABLE I.

Age groups (years)	Hospital cases		Maternity home cases	
	Primigravidae	Multiparae	Primigravidae	Multiparae
15–25	117	4	72	15
26–35	79	32	36	49
36+	10	15	2	12
Total	206	51	110	76

In all cases routine antenatal supervision was carried out, and in addition the diet, economic status, nature and duration of employment outside the home were ascertained. The hospital and maternity home where these patients were delivered used the same records for making observations during delivery, and the staff at the 2 places came from the same training school, so that the same methods were used during the confinements of the 2 groups. A patient was considered to be in labour when regular pains started, and the duration of labour was noted from this time to the birth of the baby.

In the hospital series, patients were admitted at the onset of labour. Up to this time they were either in employment or had domestic responsibilities. The cases delivered in the maternity home had a period of rest in an antenatal hostel before admission when labour commenced. All the women in this group were evacuated from London, and the length of stay in the hostel before delivery varied from 0–74 days, the average period being 26 days. During this time they helped with the domestic work in rota, had 2 hours rest every afternoon, were up at 8 a.m. and in bed by 10 p.m.

RESULTS.

A comparison of the mean duration of labour in hours between the age groups in the two series is shown in Table II.

As was to be expected, the table shows that primigravidae have a longer labour than multiparae. In the hospital series the difference at all ages is 6.7 hours, and in the maternity home 5.5 hours—values which are statistically significant. It is difficult to find statements in the literature with regard to the average duration of labour in uncomplicated cases. The textbook figures of 18 hours for primigravidae and 12 hours for multiparae are generally taken as "normal." In the present series of cases those delivered in hospital would most nearly approach this. Abnormal cases were included among the observations made by Bromberg and Brzezinski,[5] and Dieckmann and others,[1] so that comparison with their results is hardly profitable.

The "elderly primigravida" has always been a source of anxiety to obstetricians, and in discussing the average duration of labour among the cases shown in Table II, it is of interest to observe that among primigravidae over 35, the delivery averaged 14.8 ± 1.97 hours, a short time compared with the other age groups. Although the observations were made on a small

number of cases (10), it is worth noting that a completely normal "elderly primigravida" need not necessarily be many hours in labour. The 17 additional cases in this group originally all showed some obstetric abnormality and were therefore excluded from the calculations. This high percentage of complications in this age group is in accordance with observations made by others (Nathanson,[6] Walsh and Kuder[7]). Kuder and Johnson,[8] in a study of 830 primiparae over 35, found that the average length of labour was 20.41 hours, with 66 per cent complications. A search of the literature has failed to produce any figures on the normal "elderly primigravida."

Table II also shows that for multiparae and primigravidae the mean duration of labour is significantly longer among the hospital than in the maternity home cases. This is most marked among primigravidae aged 15 to 25, where the values are 17.83 and 11.96 respectively. This is a highly significant difference. As all complicated cases have been excluded from the tables, this difference cannot be explained by the fact that a hospital would tend to admit difficult cases more readily. A possible explanation lies in the difference in antenatal routine, especially the period of supervision in the antenatal hostel enjoyed by 1 of the 2 groups. If this explanation is correct, it is reasonable to expect the duration of rest to be correlated with the duration of labour. The relation may be linear or curvilinear, if, for example, residence up to a certain point is favourable, while longer periods have little extra effect. Consequently the mean duration of labour for differing periods of antenatal residence was calculated among the primiparae aged 15–25 delivered in the maternity home. The results, which are given in Table III, are surprising because a positive correlation is shown.

For a period up to 9 days the mean duration of labour is 7.64 hours, while for women who were in the hostel more than 40 days the duration of labour was 13.71 hours—80 per cent greater. The correlation coefficient between the two variables was +0.272 which, though not a large value, is statistically significant. For the

TABLE II.

Mean Duration of Labour in Hours.

Age group	Hospital cases	Maternity home cases	Difference Hospital—Maternity home
Primigravidae			
15–25	17.83±1.29	11.96±0.59	5.87 Highly significant
26–35	17.25±1.49	13.96±1.35	3.29 Not significant
36+	14.80±1.79	*	
All ages	17.46±0.93	13.12±1.43	4.34 Highly significant
Multiparae			
15–25	13.12±4.66	6.45±0.85	6.67 Significant
26–35	10.01±1.37	7.96±0.74	2.05 Not significant
36+	11.63±1.97	7.56±1.31	4.07 Not significant
All ages	10.73±1.08	7.60±0.55	3.13 Highly significant

* Numbers too few for analysis to be profitable.

older primigravidae and for the multiparae, the correlations were also positive, but not to a significant degree.

In the report on "Women in Industry"[9] made in 1919, the conclusion is reached that light factory work is not prejudicial to pregnancy. Eastman[10] supports this view and indicates the desirability of employment with adequate precautions up to 6 weeks before term. The difficulties involved in making reliable observations on this matter in factories are pointed out in papers by both Silverman,[11] and Olsen,[12] who considers the first 3 months to be the most hazardous, and the middle 3 months to be the safest in industry. O'Sullivan and Bourne[13] indicate the lack of standards in industry relating to supervision during pregnancy. They studied 90 cases in which antenatal arrangements were satisfactory. Normal deliveries occurred in 77 cases which were followed up.

In view of the controversy, more apparent during wartime, over the optimum time at which to stop work during pregnancy, it is of interest to consider whether there is any correlation between duration of labour and the month of pregnancy in which work ceased in the present series of cases. The correlations are shown in Table IV.

TABLE III.
Primigravidae aged 15–25 years.

No. of days spent in antenatal hostel	No. of cases	Mean duration of labour (hours)
0– 9	11	7.64
10–19	17	10.94
20–29	22	11.46
30–39	15	12.00
40+	7	13.71

TABLE IV.
Correlation Between the Duration of Labour and the Month of Stopping Outside Work in Normal Primigravidae.

Age group	Hospital		Maternity home	
15–25	−0.178	Bordering on significance	0.085	Not significant
26–35	−0.111	Not significant	−0.102	Not significant
36+	−0.103	Not significant		
All ages	−0.148	Bordering on significance	0.076	Not significant

None of the values are of definite statistical significance, but the fact that they are mainly negative in sign suggests that too early cessation of outside work is not always favourable to short labour. Further observation and research is required on this important subject.

BREAST FEEDING

Records were available only for the first fortnight of the child's life. Unfortunately, it was not possible to follow up these patients after discharge from hospital, and the study of breast-feeding after the first 2 weeks had to be abandoned.

The findings are given in Table V, which shows the classification of the babies of primigravidae admitted to the maternity home, according to the length of residence

in the antenatal hostel and varying ability to breast feed during the first fortnight.

The distributions are very similar, and, when the appropriate statistical test was made, it was found that there was no evidence to show that the time spent in the antenatal hostel is a factor of importance in breast feeding during the first fortnight of life. A similar result was obtained when the month of stopping outside work was considered.

TABLE V.

Type of feeding	Duration of residence in days 0–19	20–29	30+	Total
Breast fed	25	33	25	83
Breast fed with supplement ...	6	5	9	20
Bottle fed	5	7	6	18
Total	36	45	40	121

BIRTH-WEIGHT.

The mean birth-weights of the babies for primigravidae in both places are given in Table VI.

TABLE VI.

Age of mother	Sex	Hospital cases Number	Hospital cases Weight in pounds	Maternity home Number	Maternity home Weight in pounds	Difference Hospital—Maternity
15–25	M	58	7.40±0.11	30	7.36±0.12	0.04
26+	M	42	7.24±0.13	21	7.57±0.18	−0.33
15–25	F	59	7.24±0.11	27	7.27±0.11	−0.03
26+	F	45	7.23±0.13	17	7.20±0.19	0.03

This table confirms the observation made by many others that boys are heavier than girls at birth. But there is no evidence that the antenatal routine has any influence on the birth-weight of the baby in either group, as the differences shown in the table are not significant.

The relationship between the age of the mother and the birth-weight of the child has been studied by Martin.[14] He showed that there was a small negative regression of the birth-weight on age for primigravidae, but the present data are based on too-small numbers for comparison.

DISCUSSION.

The total numbers in both hospital and maternity home groups are adequate for statistical analysis, but when these groups are subdivided according to the age and parity of the mothers, the small numbers among the primigravidae over 35, and the multiparae under 25, are noticeable. Any conclusion drawn from these groups must therefore be accepted with caution. It would have been of great advantage if more subjects could have been included in the investigation, but unfortunately this was not possible, as the antenatal hostel and maternity home closed in the middle of 1945.

That there is a difference between the length of labour of cases delivered in the two places is apparent, but the reason for this difference, which at certain ages is marked, is not so obvious. As far as could

be ascertained the 2 groups were alike, and their treatment during delivery was similar. There is one point which must be considered, and that is the question of medication during labour. Gas and oxygen was used in practically every case for the actual delivery, but it is quite possible that analgesic drugs were used to a greater extent in the hospital cases. Every patient reacts differently to drugs, and this brings in the individual human element which it is impossible to assess, even though the same drugs were used in both hospital and maternity home. It is difficult to believe that the giving of drugs alone would have made such a marked difference in the average length of labour.

There is, then, the question of residence in the antenatal hostel, the most obvious factor in which the 2 groups are unlike. It alone cannot account for the fact that the mean duration of labour was significantly longer amongst the hospital cases. For, when the period of residence was correlated with the length of labour in the primigravidae admitted to the maternity home, it was found that the longer this period, the longer the labour. This was especially true among the mothers under 25. Over this age the correlation was not significant. Whether this finding can be accounted for on psychological grounds is debatable, but it is possible that in the maternity home the fact that everyone was undergoing the same normal physiological process, and that the atmosphere was not austere, contributed towards a shorter labour than that found in the hospital wards, where there was necessarily a more rigid discipline. Again, too long a period at the hostel with few responsibilities may not be beneficial, as it allows more time for vague fears, or for anxieties in connection with absence from home, to accumulate. Fear is believed to be an inhibiting factor during delivery and is often manifest, in other circumstances than labour, as failure to relax or as positive spasm in both skeletal and plain muscle.

If the explanation for the differences found in the length of labour between the 2 age groups has a psychological origin, as has been tentatively suggested, further research to elucidate the problem will be needed. A longer follow-up of patients is also desirable.

Summary and Conclusions.

Two groups of normal maternity cases were compared in the following particulars: length of labour, and birth-weight of child. One group was admitted in labour and delivered in hospital; the other group had had a period of residence in the antenatal hostel before admission to a maternity home for delivery. The ability to breast-feed during the first 2 weeks of the infant's life is considered in its relation to the duration of antenatal residence in primigravidae.

The mean duration of labour was significantly longer in the hospital series, both for primigravidae and multiparae. No significant difference was found in the birth weights of the infants. No significant difference in the initial ability to breast feed in relation to the duration of antenatal residence was revealed.

The difference in length of labour could not be accounted for by the duration of antenatal residence, for among the primigravidae aged 15 to 25 a significant positive correlation was found between length of labour and days of residence.

It is suggested that the findings might be accounted for on psychological grounds, but further research is required for proof.

Acknowledgments.

It is a pleasure to record our thanks to Dr. H. C. Jennings, Medical Officer of Health, Oxfordshire County Council, for permission to make these observations at

the Emergency Maternity Home, to Dr. Patria Gairdner who helped to launch the investigation; to Professor Chassar Moir and Mr. J. Stallworthy for allowing us facilities at the Radcliffe Infirmary; and to the Nursing Staffs at both places for their willing co-operation. We are indebted to Dr. W. T. Russell for statistical advice, and to Professor J. A. Ryle for help and criticism.

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Full-Time Secondary Abdominal Pregnancy with Delivery of Living Child

BY

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THE delivery of a full-time living child after a ruptured ectopic gestation is very rare. Only 20 cases had been recorded up to 1935 and in many of these cases the child died soon after birth[1]. The following case is therefore worth noting.

The patient, a Hindu woman aged 28, was admitted from the Out-patient Department on August 25th, 1944, because of slight pelvic contraction and non-engagement of the foetal head, in spite of the fact that she had reached term and was a primigravida.

Her pelvic measurements were: intercristal 9 inches, interspinous 8 inches, external conjugate 6½ inches, intertuberous 3½ inches—not unusual ones for a patient of her race. The foetal head could be felt below the umbilicus and the limbs were easily felt anteriorly and to the right. Foetal heart heard to the left of the umbilicus. Otherwise nothing abnormal was found on general or local examination.

By 3.15 a.m. on 26th October, 1944, labour pains, which had started at 11 p.m. the day before spontaneously, had become severe and frequent and the patient was sitting up in bed and crying out.

At 3.30 a.m. abdominal examination showed a tender abdomen, head still above the brim of the pelvis. On vaginal examination the os admitted 1 finger; membranes or foetal parts were not felt. The promontory was not felt but the pelvic brim was found to be rather narrow in its transverse diameter. A thick white mucoid discharge was seen on the examining finger.

Morphia gr. 1/8 and atropine gr. 1/100 were then given. At 5.30 a.m. when I saw the patient for the first time, she was getting strong pains almost continuously without engagement of the head or dilatation of the cervix. The presenting part could not be felt *per vaginam* and fluid was not being passed. *Per abdomen*, apart from the head felt prominently bulging in the left lower quadrant, the other foetal parts were obscured by straining efforts on the part of the mother and the tenderness of the abdomen. Foetal heart-rate 150 per minute. Mother's pulse 94, temperature 99° F.

The diagnosis was made of malpresentation due to a soft tissue tumour or twin preventing engagement of the head.

Under local novocaine and light ether-chloroform inhalation anaesthesia a sub-umbilical incision was made with a view to performing a lower segment Caesarean section. On opening the abdomen a little bloodstained fluid appeared and the condition of affairs depicted in the drawing was seen (Fig. 1).

The child, completely covered with its smooth opaque gestation sac and membranes, was lying in the first vertex position entirely outside the uterine cavity, with the head in front and to the left of the uterus, which was itself tilted to the left and posteriorly. The placenta could be made out

through the membranes, attached to the posterior wall of the uterus in the region of the fundus and right cornu. The right Fallopian tube, round ligament and ovarian ligament entered the gestation sac here inserted almost together into the left cornu of the uterus, which was well down in the true pelvis, and the uterus here looked like an ordinary puerperal uterus about the 4th day of the puerperium.

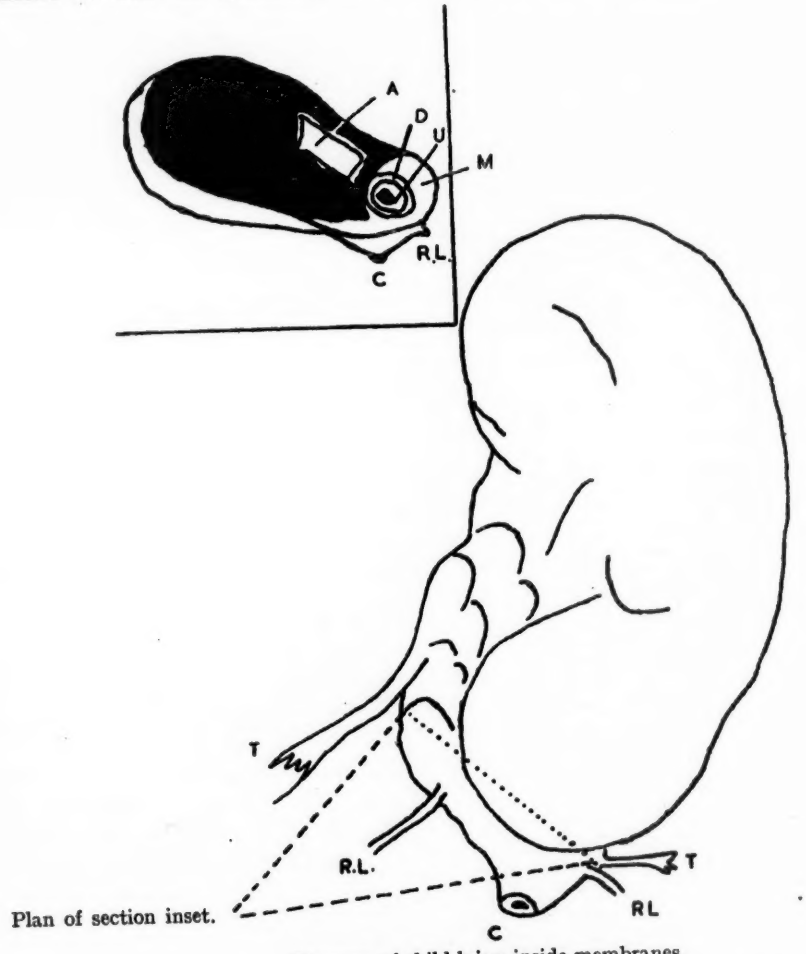

Diagram of child lying inside membranes.

T, Tube; RL, Round Ligament; C, Cervix; A, Amniotic Cavity; D, Decidua; U, Uterine Cavity; M, Muscle.

widely separated from one another. The distance between the insertions of the ovarian and round ligaments was at least 2½ inches.

On the left side the 3 structures were

After packing off the intestine and dividing a few omental adhesions the membranes were incised and a living child (7 pounds, male) was easily delivered and cried at once. It was perfectly formed.

The placenta could now be seen filling the whole of the right lower half of the gestation sac and so intimately fused with the structures in the region of the right uterine cornu that it seemed to form a part of the right uterine wall here.

As the uterus was obviously of no further use as such it was removed by subtotal hysterectomy, together with the right tube, ovary, placenta and membranes, and the abdomen was closed. There were only a few fresh clots in the pelvis at the end of the operation. The small intestine contained many round worms.

Puerperium. This was quite afebrile except for a rise of temperature to 99.6° F. on the second day. The patient was able to feed her baby and left hospital, with the wound well healed, on the 18th day, the baby having gained 4 ounces in weight.

On going carefully into the previous history of this patient after the operation, she said that in her village, when about 4 months pregnant, she suddenly felt faint and fell to the ground. This was followed by pains in the abdomen for about 2 days but she had no vomiting or vaginal bleeding. From the 7th month onwards she had had occasional pains in the right lower quadrant of the abdomen. She made only one visit to the antenatal department when she was at term and was then admitted.

Pathological Report. The specimen shows a puerperal uterus amputated in the region of the internal os, with the right Fallopian tube, ovary and stump of the right round ligament attached to it at widely separated intervals of over 2 inches on the right side. The stumps of the left tube, ovarian and round ligaments are inserted close together in the normal way on the left side. The right border of the uterus is 4 times as long as the left, measuring from the cervical canal to the tubal insertion, and is largely made up of the tissues of a full-time placenta which has infiltrated and destroyed the musculature in the region of the right cornu. The placenta spreads across the uterine cavity to the left and posterior aspects and forms the floor of the gestation sac, which is completed by the amnion and thickened chorion laeve. Pieces of omentum are adherent to the latter at one or two places. The main part of the uterine cavity is not occupied by placenta and is lined by decidua about ¼ inch thick, pale in colour and showing no haemorrhages.

Fig. 1 is a drawing showing the appearances at laparotomy. Inset is drawn a cross section of the specimen from below the insertion of one tube to below the insertion of the other. In this the smaller, thick-walled pale end shows the main uterine cavity (U), decidua (D) and uterine muscle (M). The dark and large end is the cut placenta. At about the junction of the 2 and rather nearer the posterior surface (upper part of the diagram) a portion of amniotic cavity (A) has been cut through and shows as a rectangular cleft of the drawing.

Histology. The report of Dr. J. G. Parekh, M.R.C.P., Pathologist, Sir Jamsetjee Jeejeeboy Hospital, was that no uterine muscle could be found in the region of the right tubal insertion. Here it had been entirely replaced by the chorionic villi and blood sinuses of the placenta.

Other sections showed a normal uterine muscle and decidua lining the unoccupied uterine cavity and a gradual thinning out and disappearance of the muscle as the gestation sac is approached.

Comment. The chief interest of this case lies in its rarity. According to Mall[2] less than 1 per cent of all cases of ectopic gestation go to term. In Wilson's case[1] the baby weighed 5¼ pounds and was estimated as of 8½ months gestation. He states that up to 1935 there were only 40 recorded cases of delivery of an abdominal pregnancy at term and of these only 20 children were

born alive. One surprising thing about these reported full-time extrauterine pregnancies is that in many the child was found free in the abdominal cavity and not surrounded by its membranes, that is, development had continued in spite of rupture of the amnion. The late Colonel Plumptre, I.M.S., told me of one such case he had had in his early days in Kathiawar (unpublished), when the baby's back presented in the abdominal wound made at the operation for Caesarean section. He started to incise this, thinking it to be the uterus. It was not till ribs were encountered that the true condition was discovered. Mother and child both recovered uneventfully.

Other cases reported include those of Bogdamvics[3] and Du Bose.[4] In both there was a simultaneous intrauterine twin pregnancy: and in both the 2 children were successfully delivered alive, but 1 child died soon afterwards. Novak[5] collected 9 such cases where both children lived.

Apart from its rarity, this case is remarkable for the situation of the rupture, which must have taken place in the interstitial portion of the tube at about the 4th month. This type of rupture is said to be followed by very profuse bleeding and yet at operation only a little pink fluid was found in the abdomen and not many adhesions. It would seem that here the rupture occurred very gradually through the upper part of the tube where the chorion laeve happened to be situated, so that the big placental sinuses were not affected. The placenta then continued to grow at the expense of the uterine muscle since there was no proper decidua in this region to protect the muscle from its eroding action.

SUMMARY.

1. The delivery of a live full-time child in a case of secondary abdominal pregnancy is reported, the ovum being originally implanted in the interstitial part of the tube.

2. It was not an angular pregnancy since the attachment of the tube, round ligament and ovarian ligament would then have been close together on the outer side of the gestation sac and not widely separated as in this case.

3. A brief review of the literature is made.

I have to acknowledge the great assistance of the House Surgeon, Mr. J. A. Castellino, M.B., B.S., both for his preoperative notes and his help at the operation. My thanks are also due to Dr. J. G. Parekh, M.R.C.P., who prepared the histological sections and reported on them, and the College artist, Mr. R. G. Gupte, who took the photographs from which the drawings have been made.

I have to thank also Lt.-Col. Jelal M. Shah, O.B.E., I.M.S., for permission to publish this case.

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ROYAL COLLEGE OF OBSTETRICIANS AND GYNAECOLOGISTS

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INDEX TO CURRENT LITERATURE

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Any inquiries should be addressed to Miss D. F. Atkins, British Postgraduate Medical School, Ducane Road, London, W.12.

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